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POWER FOR WAR*

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HISTORY OF POWER IN 90 SECONDS

For ages, man's only power was his own muscle power. Then he made animals and slaves work. Then his sailboats and windmills got power from the air. He turned wagonwheels into paddlewheels and got water power. He discovered fire and burned wood, to make light, to keep warm, and drive wild beasts away. Then discovered "roast pig," only after his house burned down (according to Charles Lamb). For ages he boiled water and wasted the steam. He didn't know that steam had any power. He burned charcoal, and then coal to cook, and to smelt metals with. When he invented gunpowder he made mixed chemicals work. So he got POWER from POW-DER!

The cannon was the first heat engine—it got power from heat, and for centuries the cannon was the *only* heat engine. Then man built engines to use the power of steam; and later on, others to use gas, gasoline, kerosene and oil power.

Meanwhile he studied thermo*dyn*amics, invented *dyn*amite, and built *dyn*amos that made electricity. Then he made electricity work, to make light, to telegraph and telephone and crush rock, and to pump oil and gas 1000 miles, to roll steel, pull trains, make ice, and produce new light metals unknown to former generations; then to weld metals, tell time, and teletype, and send wireless messages. But radio and television had to wait for electronics.

* An address before the Annual Convention of the Central Association of Science and Mathematics Teachers November 24, 1944, at the Stevens Hotel in Chicago.

"Power for War" is a timely subject, and one with a history. When Carthage was at war with Rome, the great African General, Hannibal, shipped elephants across the Mediterranean to help his army climb the Alps and invade Italy from the north. Hannibal used elephants—"Power for War."

The armies of Napoleon could not march any farther in a day than those of Alexander the Great who lived 2000 years earlier. Because, despite the passing of twenty centuries, the railroad had not yet been invented! George Washington never saw a railroad. In World War I, there were plenty of railroads in Europe but their automobiles, tanks, trucks and planes were very backward affairs. Our airplanes now, compared with then, can carry nine times the load, seven times as far, three times as fast and three times as high.

Our airplanes, made since Pearl Harbor, have six times the power of the United States plus the British Navies. Our railroad locomotives have 150 million horse power. The electric light and power plants of all kinds have over 100 million horse power. And we must not forget the humble canal-boats, or the bigger river boats, or the still bigger lake boats, or the Merchant Marine, or the Navy. All of them need power for war.

Each battleship needs as much power as a city of 200,000 population. In all the world there are only ten hotels with as many as 2000 rooms. This hotel is one of these, but some of our ships house and transport 5000 men! So they are supermammoth hotels that must carry their own food and refrigeration and kitchens, and huge power plants that must carry their own fuel; and huge floating forts that must carry their own ammunition.

And the pipe lines carry gas and oil for power for war. And the copper cables carry electricity. The electrical industry is a young industry, and I can prove it:—I was alive when Edison invented the first incandescent lamp! So in just one lifetime, the electrical manufacturing industry (where I work, in Schenectady, New York) and the electric light and power industry that lights your lamps, etc.—have spread all over the civilized world. And because both of these industries started in the U.S.A. and also because we are hustlers, we Americans now use about one-third of all of the electric power in the world!

Now because the electric power and the electric manufacturing industries are both so young, they fairly bristle with little-known facts—some of them of a really "Believe it or not"

nature. In the next twelve minutes I will review some of the little-known facts about electricity that I never learned in college.

When you buy electricity, you buy work—muscle work—not brain work. You can accurately and scientifically express a kilowatt hour directly in foot pounds. Many people, it is true, think that you must say "foot pounds per minute" or "foot pounds per second," but that is not correct. When you buy electricity you buy it by the kilowatt hour, and a kilowatt hour is 2,656,000 foot pounds of work. That is more work than the work done by a man climbing to the top of the Chicago Tribune Tower—39 times! Whether you walk upstairs or run upstairs, the work is the same. But when you *run* upstairs you exert more power, i.e. more watts.

"What's a Watt," Demonstrated on Television

Our Television Studio, WRGB, in Schenectady, has broadcast many science programs by television. One last summer demonstrated:—"What's a Watt."

Now, a watt is $44\frac{1}{4}$ foot pounds of work done in one minute. So it is a measure of *power*. The props for this television show were quite simple:

A table, 44 cans of food on the table, each can weighing one pound, and a shelf one foot above. And a clock.

So when a person puts one can up on the shelf he does one foot pound of work.

Miss Muriel Fulmer, one of our technical writers, volunteered to act as a guinea-pig in this test. In the first rehearsal she used *both* hands, and found it was *easy* to put all 44 cans on the shelf in one minute. But in the second rehearsal she tried it with only *one* hand, and found that she *just barely could do it!* She had to work so hard her arm got tired. And she had to hustle so fast she had no time to arrange the cans—some were upside down, some labels faced the wall.

So the studio audience and also the television audience could see just how much power one watt really is.

The final performance was made with one hand. A large clock in full view of the audience added drama. It was a special clock with only one hand:—a big black hand and that made just one revolution in one minute. All could watch the remaining time grow less as the remaining pile of cans grew less. This revealed to all that the experiment was really a race against time. And Miss Fulmer just barely won it!

What the Test Taught Us

First, it showed that the power of one watt will tire out one arm in one minute. Miss Fulmer is not a "Society frail" but a strong athletic girl. Second, if she had tried to do that job in one-half of a minute, she would have had to work at the rate of two watts, and she then surely *would* have had to use both hands. Third, if she had taken two minutes to put the cans on the shelf, she would have been working at the rate of only one-half of one watt. But in all three cases, the *work* would have been the same. The mechanical engineer would say the work was 44 foot pounds. The electrical engineer would say it was (approx.) one watt minute. But whatever you call it, that work tired the girl's right arm.

Now, Miss Fulmer did only one watt *minute* of work, but the work in one kilowatt hour, is 1000 times one *watthour*. So the work in one kilowatt hour is 60,000 times as much work as she did. Another little known fact about electricity is that 1000 watt hours or one kilowatt-hour equals 2,656,000 foot pounds. To do that much work, Miss Fulmer would have to put 2,656,000 cans up on the shelf. They would weigh 1300 tons! They would fill 26 modern freight cars!! And working at the same rate of one watt, it would take her at least 4 months to put all the cans up on the shelf!

One can learn many interesting things in a television studio. One thing that surprised me was that the television cameras have no motor, and no moving parts, and make no sound! The same is true of the television receiver in your home. There are no motor noises to detract from the reception of the program itself.

The next morning, after the "What's a Watt" program, one man said to me "I *saw* you last night on the television." Ten seconds after I left his office, another man (in the hall) said "I *heard* you last night on the television." Thus, the way television combines seeing and hearing on the part of the audience was brought to my attention in a sudden and an amusing way. That suggests a new word "serd"—which combines *saw* and *heard* into *serd*. So television resembles talking movies in that you can both see and hear. But television can let you see and hear the news, etc. *while it is happening*.

Talking movies show what *did* happen—so they are in the "past tense"; but television can be either in the present tense, or in the past tense. For example:

The evening program at WRGB presents two different kinds of shows:

1. The "present tense" show, given by the actors, musicians, lecturers, etc. You see and hear them *while* they perform in the studio; and
2. (Here was the surprise for me)
The "past tense" show which consists of talking movies, from regular film!—where you see and hear actors, perhaps 6 months *after* their performance in their studio.

These films are completely reproduced, sound and all, in *all* the television receivers—both inside and outside the studio—and even far outside the city.

So a good television receiver lets you see and hear the news *while* it is happening; and it also is a miniature talking-movie theatre, needing no projector, no screen, and no moving parts, and no operator—you don't even have to change reels or rewind them! Here's how it's done at Studio WRGB. The television camera includes a sensitive plate. The movie projector is focussed so as to throw the picture on this plate. The tube broadcasts the movie. The sound is superimposed, so your home becomes a miniature movie theatre.

Perhaps schoolrooms will contain television receivers. Already the schools of Cleveland now have loudspeakers which provide special educational programs broadcast by radio from the Board of Education's handsome downtown headquarters.

Now back to little known facts about electricity: No man can make a kilowatt hour in a day. The work in one kilowatt hour is more work than any man can do in a day. A day of hard labor by a strong man is never as much work as the work in one kilowatt hour—no matter how long the day, or high the pay! Even an athlete, striving for fame, cannot in a whole long day do as much work as the work in four cents' worth of electricity. Not even the winner of a marathon race! At Niagara Falls, *ten tons* of water must make the drop in order to make one kilowatt hour. But in a modern steam power plant, one pound of coal will make one kilowatt hour. So you see, one pound of coal will make as much electricity as 20,000 pounds of Niagara's water. (See Appendix B.)

First, for instance, take the bicycle generator. We have made several of them. You climb on and pedal and that turns the generator attached to the back wheel. In that way you can light a 100 watt lamp for a little while. But we wanted an expert to try it. So one bicycle generator was taken down to Madison

Square Garden in New York, while the six-day bicycle race was on. We have a fine photograph of the French champion, Mr. LeTournier, dressed in his racing suit, peddling our bicycle, equipped with his special curved racing handle-bars, and rubber and steel toe-clips to keep his feet from slipping off the pedals. And there he is, making a desperate sprint! You can see the effort he makes, because the tendons stand out in his neck, and behind his knee. He burned a 100 watt lamp longer than anybody else did. Then he stepped off, breathless, and we read the meter. It showed that he made 1/2000th of one kilowatt hour. So he would have to get breathless 2000 times before he made 4¢ worth of electricity!

And we figured out, from that meter reading, that if he and his teammate had been able to keep up that sprint speed six days and six nights, the two together would have made seventy-eight cents worth of electricity *that week!* That's pretty poor pay for two internationally famous athletes, in the prime of life and in the pink of condition.

And then the Army and the Navy have hand generators. There is a crank on each side, and you turn the cranks with both hands. You turn them sixty revolutions per minute; it makes 60 watts for radio messages from the jungle and from life boats and in fact any place, where there isn't any socket to plug into. The manufacturers in Erie, Pennsylvania have sold more than 60,000 of them, all over the world. The over-all efficiency from your muscles to the electric wire is almost 60%—which is very high for so small a machine—and it's *geared up,* from 60 RPM to 1800 RPM!

Well, I got hold of one of those and rigged it up in my office, clamped it on to a steam pipe; wired it up to a 60 watt lamp and sure enough, I lighted it with my own muscles. But the racket went through the piping system, and some of my office neighbors came in and complained about the noise. I said:—"You turn the cranks, and see what it feels like to take 60 watts out of your breakfast, and light that lamp with it."

Many tried it, but none turned it longer than a minute. I remarked about that, and just then a strange voice spoke up behind me:—"What will you pay me if I keep the lamp going for *five* minutes?" I turned around and there stood a husky young porter that works in our building. "Come right in," I said, "and I'll pay you a dollar if you keep the lamp lighted for five minutes, $2.00 for ten minutes, $3.00 for fifteen minutes,

etc. As long as you keep that light burning your rate of pay will be—let's see, that's $12.00 an hour!"

His face lighted up, his coat came off, and when he started in he was smiling and confident:—*when he started in!* But in just thirteen minutes he quit, dripping with perspiration, utterly exhausted and panting for breath. I paid him a little over $2.00 and said, "Why didn't you keep it up? $12.00 an hour is higher pay than you get moving furniture or washing windows." And he gasped: "The money wasn't—worth the work!"

And what was the work? Work is power multiplied by time. The power he delivered to the lamp was 60 watts. The time which he delivered it was thirteen minutes. So when you multiply them, you see the work he did was just a few watt minutes! It is easy to see what a pitifully small fraction that is of a kilowatt hour, which is 1000 watt *hours!*

Now, let's continue our investigation of little known facts about electricity. You do know, of course, that electricity is divisible into light and power and heat and electronics. But how about the degree of light which the electric lighting industry has developed? Up in an airplane, on a clear night, you can read a newspaper by the light of an Army or Navy searchlight six miles away on the surface. And light is divisible all the way down to the little "grain of wheat" lamp that the doctor puts down your throat to help him see.

And electric *power* is divisible, all the way down from the huge motors that run the steel and cement mills, and locomotives, down to that popular little motor that runs the dentist drill, or the little Selsyn motors that help aim big guns on our battleships, or the little 2-watt motor that runs an electric clock. This motor turns 5 million revolutions a day, and many run 10 and 20 years without attention. Millions of motors are hardly larger than a spool of thread.

And electric *heat* is divisible, all the way down from the terrific temperatures of the electric furnaces, down to the gentle warmth of the heating pad that relieves the baby's earache. The heating pad, of course, developed into the electric blanket, and that developed into electrically heated clothing—coats, trousers, gloves, shoes and goggles, worn by our brave flyers six miles up in the sky, where it is eternal winter—60 degrees below zero even in the summer.

Did you know that our flyers also wear electrically heated goggles? They protect his eyes from the wind and the cold in

those ghostly regions of the sky where grease freezes and metals shrink and men need protection from the wind and the cold. The heating wires are no larger than threads, and run up and down, buried inside the plastic glass in the goggles. This prevents the goggles from becoming frosted over with freezing fog that blinds the flyers. The amount of electric power needed to keep a six foot flyer warm, from his eyebrows down to his big toes, is 280 watts; or about half of the power needed to toast a slice of bread.

Perhaps you have never stopped to think that electric light is flameless light, electric power is flameless power, and electric heat is flameless heat. In an airplane, 25,000 feet up, a candle sputters. It goes out at 33,000 feet and you can't light it again up there. But electric heat is just the same six miles up as it is at sea level—it is independent of the atmosphere—there is no combustion. It gives heat without needing any air.

And besides being divisible and flameless, electricity is versatile. A horse can pull a load but he can not vacuum sweep your floor. Electricity does both. You can refrigerate with ice, but ice will not run an x-ray machine at the hospital. You can cook with several different kinds of fuels, but not one of them will run your radio. So you see, you can load scores of different jobs on electricity's shoulders. And when you do, you will find that he is Jack of all trades and master of *all*.

Did you know, too, that in American industry, there is an average of $6\frac{1}{2}$ h.p. of electric motors for every factory worker, average for the 6 foot man, and for the 5 foot girl. Now $6\frac{1}{2}$ h.p. is about 4800 watts. Strong men, however, are able to exert only 35 watts and keep it up all day. That is the power of a strong man—35 watts throughout the day, at the average task. Well you see, the factory boss provides him with 4800 watts or 140 times as much power as the man himself possesses. So his output is increased at least 140 fold. And perhaps a five foot girl's output is increased 280 fold because the fair sex is the weaker sex. That's why girls can work in factories now. They don't have to pull on heavy chains, or throw ponderous levers, or turn iron cranks, or lift heavy loads. No, they just sit there, and push buttons, and step on pedals. Most girls in factories do not do as much physical work as waitresses in restaurants or chambermaids in hotels.

Then take electric welding. Electric welding builds ocean ships faster; electric welds take up less space than riveted joints do; they save material and that saves weight. Electric welding

reduces the number of parts, and saves time too—especially spot welding.

New Metallurgical Age

Another fact—this war has catapulted America into a new metallurgical age. When I was a baby they finished the Washington monument and at the top they put a little pyramid of aluminum 6 inches by 6 inches by 9 inches high. It was the biggest aluminum casting in the world—it weighed 26 ounces. It is still there and in good condition, I am told. Then, aluminum was a laboratory curiosity, it was a museum specimen, and it cost around $100 a pound. When I went to grade school at Indianapolis, aluminum cost $10.00 per pound and there wasn't any in our middle-class home. When I went to college at Purdue, aluminum cost $1.50 a pound, and they told me *some* of it was made the new electric way. When I got my present job with General Electric Company, aluminum sold for 28¢ a pound and *most* of it was made the electric way. Now it costs 15¢ a pound and it's *all* made the electric way. The electric way is the *only way* in which aluminum and magnesium can be made quickly, and cheaply, and in vast quantities. There *is no other way* to make these wonderful new metals, unknown in former generations and unused in former wars, yet vital in this war right now!

Electricity is not a mere adjunct in making aluminum—it is a prime necessity. Electricity is indispensable in making a lot of aluminum quickly and cheaply. A lot of aluminum is indispensable in making a lot of airplanes. A lot of all metal airplanes are indispensable in gaining air supremacy. And air supremacy was and is indispensable in our successful invasions. In fact, it preceded our invasions. When the air is ours, we have won the war.

In the airplane industry, there are 300 weight engineers whose job it is to lessen the weight of planes and things that go into planes. That's why they specify aluminum for the wings and for the cabin, and magnesium for various parts of the engine. It takes 20,000 KW hours to make a ton of magnesium, and 20,000 more KW hours to make a ton of aluminum. It takes only 90 KW hours to make a ton of Portland cement.

It takes 18,000 KW hours to make a ton of Alnico, the new permanent magnet. This is 30 times as powerful as the best magnet 30 years ago. Every pound of Alnico used in an airplane saves five to ten pounds of weight. They are used in motors,

instruments, magnetos and some day they will be used in generators. The reason they save weight is because when you *buy* magnetism in this form, put up in this package at the factory, you do not have to *make* magnetism with heavy electro magnets containing thousands of turns of copper wire. Alnico magnets also save gas. Because when you *buy* factory-made magnetism, you don't have to burn gasoline to *make* it on the plane. (See Appendix E.)

It takes 100,000 KW hours to make a ton of Carboloy. This is a cemented Tungsten carbide which cuts steel six times faster than it has ever been cut before, without tools getting dull rapidly. This will cut steel all day at high speeds. It stays sharp even after it gets red hot. And it is so hard, it will scratch glass. Carboloy weighs $\frac{1}{3}$ more than lead, and magnesium weighs $\frac{1}{3}$ less than aluminum.

When a tool that is tipped with Carboloy finally does get dull, they can sharpen it in a few seconds on a diamond wheel. Here is a $50 diamond wheel with hundreds of thousands of little diamond chips embedded in the rim of the wheel.

And drills, tipped with Carboloy, will drill a hole through a brick, and come out sharp on the other side. Here is a file with a nice bright hole drilled through it. And it was a very hard file too. When I made that statement to an audience of 1000 young men, and told them that it was a *very hard file*, a murmur swept through that auditorium from front to back. That was at the Elmira Reformatory. And I don't mind telling you that I couldn't see any difference between a reformatory and a penitentiary, and I have been in both! Buildings and equipment look just exactly like a penitentiary, but "students" enrolled in the reformatory were younger than the inmates in the penitentiary.

Even pistol grips are made of magnesium. And nowadays, inside of magnesium pistol grips are little electrical switchettes. They are not much bigger than a wrist watch and are made by girls. When you squeeze the trigger, the switchette turns the electricity *on*, and when you let go of the trigger, it turns it off. This is used for shooting machine guns by remote control. The gunner does not have to be behind his gun, nor he doesn't even have to be inside the turret. In the new B-29, the gunner sits *inside* the cabin and aims the guns in his turret outside the plane by remote control. When he points his sights at the enemy plane, the turret aims the guns at the right place. Then the gun-

ner pulls the electrical trigger inside the plane. Electricity pulls the trigger of the machine guns.

The biggest cartridge shot in machine guns in World War I was the 30 cal. In World War II came the 50 cal.—with five times as much striking power. The 30 cal. shoots three miles and kicks like a mule; the 50 cal. shoots a bullet nearly five times as heavy and a mile farther—although accurate aim cannot be taken at such distances.

The red paint on the tip indicates a tracer bullet. It leaves a trail of sparks at night so you can see where you are shooting. Black paint on the tip indicates an armor piercing bullet. A hard alloy slug is inside the lead which is inside the copper of the bullet. When the bullet strikes, the lead and copper mushroom, and that forms a kind of hollow funnel which keeps the sharp pointed alloy slug pointed straight ahead, and so helps prevent it glancing off.

Also in World War II came the 20 mm. automatic cannon which shoots steel shells of various kinds. The automatic cannon shoots 10 shots a second, the same as the 30 and 50 calibre machine guns. So the automatic cannon is really a machine gun but of cannon size. The shells it shoots spin around between 90 and 100,000 revolutions per minute. That is about 1500 revolutions every second. You can wink three times in a second; so these bullets spin around 500 times between winks. Thus they have not only the energy due to the *velocity*, but also that hidden, stored, little appreciated energy due to spinning at that frightful rate. And when they hit, they hit all right; but they also burn and bore and drill their way through one inch of armor plate, which is five times as tough as boiler plate.

I shot 60 cartridges out of a 20 mm. automatic cannon at a factory proving ground. All I did was to press a button and hear the bang, bang, bang, 60 times in six seconds—almost a continuous flash and almost a continuous roar! The links of the disintegrating steel belt came apart and went into a steel barrel on my right, the empty shells went into another steel barrel on my left, and the bullets went out *that* steel barrel—of the cannon, in front of me!

A visitor at one of these cannon factories saw 100 shots fired just as fast as they could be fired. Then he went over and before anyone could stop him, he put his hand on the barrel. He didn't just *touch* the barrel like a woman touches an iron to see if it is hot enough, but he grabbed it. By the time they pried him loose

and dragged him away, he had left, not the *skin* of his palm but *his whole palm stuck to that hot barrel.* The doctor who gave him a shot in the arm, and first aid, and sent him to the hospital said, "I'm afraid that poor fellow will never be able to work any of his finger joints again." And it was his right hand, and he was a young man.

So the metallurgists help the weight engineers of airplane factories; and help the electrical engineers make light weight magnetos; and help the ordnance engineers in making cartridges and shells.

In the incendiary bomb you have another example of metallurgy helping the ordnance engineers. This is a genuine incendiary bomb made in Germany in 1937, and is so dated. It even has a little swastika on it. It was dropped on Liverpool but didn't go off. It has been unloaded.

The shell or casing of this bomb is made out of magnesium, which will burn when you get it started. When the bomb hits, the cap starts the thermit burning inside, and the thermit starts the magnesium, which burns at a temperature about six times as hot as your furnace fire at home. The ordnance men take advantage of the lightness of magnesium and also of its chemical properties, because the magnesium is the stuff that makes most of the heat. Or, to say it in text book language, "In an incendiary bomb, the outer shell is constructed of magnesium, and constitutes the principal incendiary ingredient," i.e. it's the stuff that makes most of the heat.

A couple of years ago, a man from London visisted Schenectady and told us of a new "refinement" in the German incendiary bomb. They had fastened a grenade to the lower end of it, and the grenade was timed to go off five minutes after the bomb landed. It was figured that when you go in with your bucket of sand to take care of the incendiary, that the grenade would take care of *you*. And he explained that even when the grenade broke off, and hid under a chair or under a table, that wouldn't help very much; because, although *you* could not see *it*, *it* might get *you*. I asked him, "What's the answer to this grenade idea?" and he answered rather glumly, "I don't know." But that was over a year ago. Shortly after, I began to see what the answer was to this grenade idea:—When the enemy air force is destroyed, bombs won't be dropped *with* grenades or *without* grenades either!

So we have the series:

Lots of good efficient power plants make lots of electricity, which makes lots of aluminum, which is needed by lots of airplanes, which gives us aerial supremacy, which will wear down and wreck the enemy air force, and destroy factories and railroads. And when the sky is *all* ours, we have won the war.

And then take the hand grenade. That is made of cast iron. So we have lead bullets, some with hard alloy cores for armor piercing, we have steel shells, magnesium incendiaries and cast iron grenades. What a galaxy of metallurgy!

When ready to throw the grenade, you pull on the ring which pulls out the safety pin. Then you must throw it in three seconds. If you wait too long it may blow your fingers off. If you don't wait long enough, the other fellow may pick it up and throw it back at you. So the job must be timed just right—or you get it going or coming.

It was discovered in this war that some of the grenades went off too soon—went off prematurely. The reason for this was found to be that the fuses inside were not brimful of powder. Here's how they discover the bad ones. For their final inspection, all *finished* hand grenade fuses parade on a conveyor belt, past an x-ray. The x-ray *discovers* if the fuse is not brimful of powder. On the other side, an electric eye *observes* what the x-ray discovers. And when a defective fuse is found, the electric eye lights a lamp, rings a bell, dobs the faulty fuse with red paint, and rings it up on the cash register. So they sound two alarms, one visible and one audible, they identify the defective parts, and they record the number of bad ones every day, so as to see what progress they are making. It is all done by electronics.

A Few Substitute Materials

Here is a fuse that fits in the nose of a trench mortar bomb. It used to take one pound of bar stock aluminum, and machine tools and skilled labor to make this fuse. Now girls make them in four minutes out of plastics. When they roll out of the mold, they roll out *finished* just as you see them now! The threads fit, even when the piece is too hot to pick up without a handkerchief. The girls even mold the *holes* and the *threads inside* the holes; and even the threads on the *inside* and *outside* of that *collar!* All they need is a little scraping or a "dry cleaning." So here plastics save aluminum, and skilled labor, and machine tools all for other uses. And what are plastics of this kind made of? Out of sawdust, coconut and walnut shells, soy beans, lamp

black, carbolic acid, shirttails, and another disinfectant. Due to the heat and the pressure, these chemicals form new materials inside the molds. These new materials have many more atoms in each molecule than the original materials which went in, and that change is called polymerization. It is something like polygamy among the molecules.

In the fuse, plastics save aluminum; but plastics are also substituted for hard wood. This gun stock is a hollow plastic molding made for shotguns. The weight engineers like them also, because they are so light and ideal for paratroopers.

Then take rubber. For insulating wires and cables, we used to have a new rubber, then old rubber, now no rubber at all. In many places, a spun glass is used in place of rubber. Spun glass is a very good insulator. When spun the right way, its tensile strength is almost equal to that of steel. It is not affected by 1200 degrees F. It defies most acids. You could boil it in salt water without damage. It is made out of sand, and there is no priority on sand.

The Japs have most of the camphor trees, so our chemists down South are now making USP 100% pure camphor out of turpentine! Now you can buy it at 10¢ a cake in the chain drug stores.

The Turbo-Supercharger

Our Dr. S. A. Moss invented the supercharger over 20 years ago. He told me the best way to appreciate the mysteries of the upper air was to stand the New York subway up on end, and take a 5¢ ride *vertically* instead of horizontally. But he advised that you take a notebook along and make written notes of your observations, because you will never live to come back and tell the story. And here is the way he described the ride:

An Imaginary Vertical Ride on the N. Y. Subway

"You start at Brooklyn Bridge and that's sea level. By the time you've gone *up* as far as the horizontal distance to 42nd St., or Grand Central Station, you are as high as the top of Pike's Peak. The thermometer is probably below freezing; your teeth are chattering, your fingernails ache. Some people are bleeding at the nose, and if you try to raise a window you will be breathless before you even *budge* the window.

"The train goes on up the equivalent of 17 more city blocks to 59th Street, where Central Park begins. Half the people are

bleeding at the nose, scores fainted, the passengers are in a panic, and the train is in a mess.

"On we go to 110th street where Central Park ends. By this time everyone has fainted; their hands, feet, nose and ears are frozen to the point of amputation.

"By the time this silent ghost train gets to the Yankee Stadium, everybody is dead and frozen solid—all for a nickel!"

Now, the passengers fainted because they did not get enough air. And the engines faint for the very same reason. A gas engine is a shrewd bargainer. Give it all the gas you can and *no* air, it will give you *no* power. Give it 100% sea-level air—it will give you 100% sea-level power. But give it only 25% air and it will only give you 25% power. One follows the other.

Engine Power Quadrupled—Six Miles Up

If you take a full breath of the *atmosphere*, you get only ¼ as much air as at sea level, and the engine would give only ¼ of its sea-level power.

But with turbo-superchargers, the engines give 100% sea-level power although amid 25% air. That means that the turbo-superchargers *quadruple* the power of the engine when six miles up. Think what that means. The four engines *gain thousands* of horsepower.

How the Turbo-Supercharger Does It

The aluminum wheel is a rotary or centrifugal air compressor. It is an aluminum forging and gets the most terrific steam hammer and heat treatment I ever saw any metal get. *That heat treatment makes the aluminum so hard that it "pings"* when you snap the corner of a blade with your fingernail. This wheel compresses the thin 25% air to full 100% sea-level air at about 14.7 lb. per square inch absolute. At the same time it heats the air. Then this air is passed through a cooler and is piped up to the carburetor where it gets the gas. Then the mixture is piped up to the engine; and on the way it is further boosted and churned up by a different kind of supercharger, which is *geared* to the engine. In the engine the mixture explodes and drives the propeller.

Now every other Army in the world throws away the exhaust gas from the engine—but Uncle Sam. For, in all of our high altitude planes, the exhaust gas is piped down to the turbo-supercharger. It goes through many nozzles and dashes against the 150 little buckets or vanes or blades in the rim of the turbine

wheel. This wheel is about a foot in diameter, is very thick at the hub and less than half of an inch thick at the rim. The gas strikes against these blades in many different places simultaneously, and makes the wheel turn around. Thus the exhaust gases furnish the power that drives the air compressor wheel on the other end of the shaft.

So it is, that the exhaust gases, thrown away by the engine, are used to quadruple the power of the same engine that threw the exhaust gases away. This seems to be contrary to the old axiom that "the whole of a thing is equal to the sum of its parts." For here a *part*, and a waste part at that, quadruples the power of the *whole* engine.

No other nation makes turbo-superchargers. Maybe they can't duplicate that turbine wheel. They all use *geared* superchargers only. We use both. It is said that even if our enemies have analyzed the chemical *content* of one of those turbine wheels, that still they would not know the processes through which it went, in order to get its marvelous endurance. It is the most tortured piece of machinery in the world.

In the 11th Psalm, 6th verse, it says, "God shall rain down fire and brimstone and a horrible tempest." This turbine wheel gets all that torture and more! These exhaust gases are *flames* and their temperature is 1500 degrees F. Sulphur and other chemicals harmful to metals are in this poisonous flame. This flaming poisonous blast strikes the buckets at a speed of 13 hundred miles an hour—while a hurricane blows only one hundred miles an hour.

This wheel must not soften in heat that would melt glass in a few seconds. It must not bend or erode in that blast raging against it at 13 times the speed of a hurricane. It must not corrode from the chemicals. It must not explode on account of the speed at which it turns. The speed is 300 revolutions per second, so they turn around 100 times while you wink once. And while doing so the turbine wheel is red hot, and the air compressor is 60 below zero. And they are only 9 inches apart.

Perhaps half an hour earlier, while on the ground, these two wheels had the same temperature. The turbine wheel *heats up* from (say) 70 degrees to 1500; while the compressor wheel refrigerates from 70 above down to 60 below. So on the way *up*, the turbine wheel expands while the compressor wheel contracts, and they are both tight on the same shaft.

Yes, these wheels are only 9 inches apart, and in between

them are both the bearings—a roller bearing near the hot wheel and a ball bearing near the cold wheel. A separate jet of oil is pumped continuously against each of these bearings.

And besides all these problems you have a balancing problem. The peripheral velocity of these wheels is faster than the speed of sound, and is as fast as many bullets. Perfect balance is needed on both of the wheels or they would explode and tear off the engine and wreck the plane.

All these are strictly *mechanical* engineering problems—and they were solved in an *electrical* manufacturing company. (Many of us believe that the electrical *manufacturing* business is 90% mechanical engineering.)

You can see this is an engineering and scientific war as well as a fighting man's war. That turbine wheel is one of the metallurgical secrets of the war. The buckets are slightly over an inch long and are electrically welded to the rim of the wheel. Tens of thousands of x-ray photos are being taken of the buckets before they are welded, and of the completed wheels. Any cracks or other defects are revealed by the x-ray, and that condemns the defective parts to the scrap pile.

In the last 40 minutes, I have tried to review some of the ways in which the electrical manufacturing industry and the electric power and light industry have been and are helping to get more weapons and better weapons quickly, to save the lives of our brave boys and help bring this war to an end—perhaps quickly. A steel man, and a rubber man, and a petroleum man, and a plastics man—they all have a story to tell too. And their stories are quite similar to electricity's story. You might say they have a common denominator. Among all industries you'll find the same things; huge plants, full of wonderful machinery; and using plenty of electricty for power and light and heat and electronics; and you'll find laboratories where scientists and mathematicians and physicists and chemists and metallurgists work and study; and you'll find skilled labor and good management, and *all* are working together, to win the war!

How long is the war going to last? Here is the same conclusion that I have used for the last two years or more:

This war will last until we swamp the enemy with brave soldiers and sailors and flyers and others, in planes that can fly farther and carry more guns and heavier guns and more ammunition up higher; and pilots that are warm and comfortable, and bright-eyed and alert, and nimble-fingered and who don't have

cold feet; and they all will swamp the enemy with ships that are making 25 to 40% more miles per gallon than those in World War I; and guns that can shoot farther and faster and harder and keep it up longer.

And that will end this war—and end it the right way!

APPENDIX A

How Long Will the War Last?

(1) Victory is a JOB—i.e it takes WORK.

(2) Work = Power × Time so—

(3) $$\text{Time} = \frac{\text{WORK}}{\text{Power}} = \frac{\text{Work of men and women}}{\text{Power of the things they work with}}$$

(4) $$\text{Time} = \frac{\text{Work of those in uniform}}{\text{The power of } \textit{their} \text{ war engines}} + \frac{\text{Work of Civilians}}{\text{The Power of their Production and Transport Machines}}$$

APPENDIX B

A Thermo-dynamic Parody on Old King Coal

Old King Coal is a powerful old soul
Every year he makes steam that is hotter.
Now a pound of coal an hour
Makes as much electric power
As ten tons of Niagara's falling water.

(Here's a quick way to check that 10 tons:

$$\text{To make 1 KWHr. needs } \frac{2{,}656{,}000 \text{ ft. lbs.}}{150 \text{ ft. (drop)} \times .9} = 10 \text{ tons of water.)}$$

The overall efficiency in First Class Hydro Power Plants is about 90% and of First Class Steam Power Plants about 30%.

APPENDIX C

Some Fun with Facts about Heat

1 BTU	= 1 pound water raised 1°F.	and
	= 778 foot pounds	or
	= 1 pound of anything raised 778 ft.	so

1 pound water raised $1°F. = 1$ pound of water raised 778 ft. or

$$1°F = 778 \text{ ft.}$$

Q.E.D.

This is a fallacy based largely on the double meaning of "raised" but it helps to show that heat as well as coal is a very concentrated form of energy.

APPENDIX D

The wireless systems of Marconi and Alexanderson were not electronic. Marconi used sparks, and Alexanderson used his high frequency alternators to throw messages from shore to ship, and across the ocean. So we had "wireless" before electronic tubes were known, and before the words "radio" and "electronics" had been coined.

History of Electronics in 90 Seconds

We used electricity for generations before we learned how to set electrons free from wires, and make them work. That's what electronics is:

The science of making free electrons work.

1. Thomas A. Edison discovered what was termed "The Edison effect." He introduced an extra wire inside a lamp, and obtained a flow of direct-current out of that wire. This lamp was a "tube" with three terminals and two filaments.

The following is approximately the order in which electronic devices have been offered to the public.

2. The first practical electronic device was the x-ray.
3. Mercury vapor lamps in long tubes that gave a green light.
4. Mercury arc rectifiers to charge batteries with.
5. Radio-telegraph and radio-telephone.
6. The electric eye.
7. Broadcasting stations and receiving sets.
8. Talking movie cameras and projectors.
9. The transmission of pictures by radio.
10. The electronic induction furnace.
11. Electronic welding, using high frequency currents generated in electronic tubes.
12. And later, this kind of welding controlled by *other* electronic tubes.
13. Fluorescent lamps.
14. Germicidal lamps.

15. Television.
16. The inductotherm, or artificial fever.
17. Radar and air navigation, not yet open to the public.

All electronic devices or systems use tubes, inside of which electrons flow.

Scientists discovered how to set the electrons free from wires, and how to control them. Then the electronic *engineers applied* the *science*, and made electrons work miracles in industry.

Electrons are tiny bits of electricity, driven from the wires, by heat, in a vacuum.

Steam is tiny bits of water, driven from the tubes by heat, in a boiler.

Electrons, like steam, are hot, invisible, travel fast, and remain free for a very short time.

APPENDIX E

What is the polarity of the top and of the bottom of cast iron steam or hot water radiators for the heating of houses? By applying a compass to the side of the top you will probably find it is South, while at the bottom, it will be North. The polarity of practically all cast iron steam and hot water heating radiators is:

South—at the top, and
North—at the bottom.

Hold the compass horizontally, and bring it close to the side of the top and then close to the side at the bottom.

A NEW EASTERN SALES MANAGER FOR SILVER BURDETT

Silver Burdett Company announces the appointment on November 1, 1944, of Mr. G. Dan Robison, Jr., as Eastern Sales Manager with headquarters in the New York Office. Mr. Robison has been sales representative in Tennessee for the past nine years, with sales responsibilities also in several neighboring states.

Formerly Mr. Robison was a teacher in the Paris (Tenn.) High School. He received his Bachelor degree from Cumberland University and did his graduate work at George Peabody College.

Mr. Robison's new duties include the sales management of all the seaboard states north of Virginia.

A NEW FLASHLIGHT

Battery-less flashlight, small enough to be easily carried about with one hand, contains an internal combustion engine of the type used in miniature airplanes and a tiny electric generator to light the bulb. A simple mechanism for starting the engine is also included.

ARCHES THROUGH THE AGES

APPLICATION TO GEOMETRY

NORMA SLEIGHT
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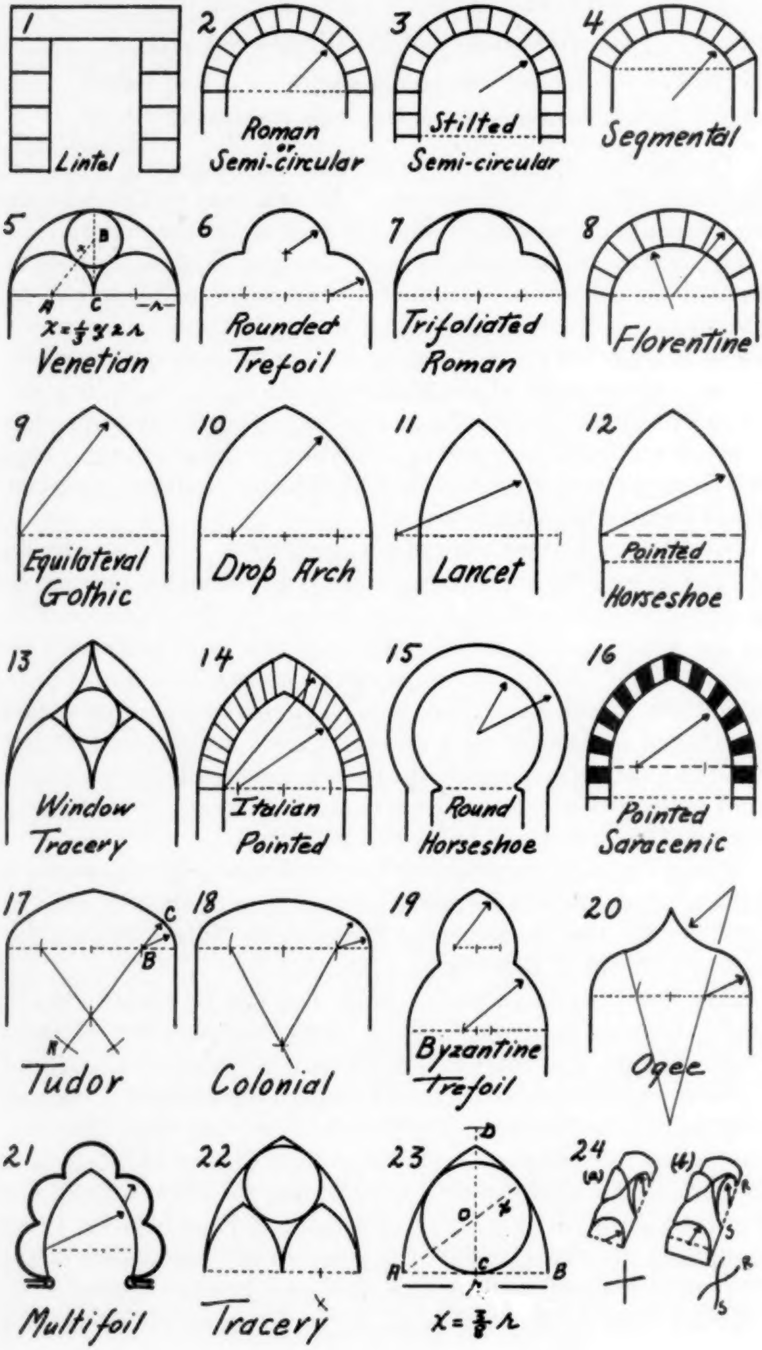
The teacher of geometry is being faced constantly with the question, "Why study geometry?" Its practical and direct uses are recognized, but few pupils will ever apply the material directly. Therefore, geometry should have something to contribute toward the general education of a child which will help him to live more richly, not just make a living. It should develop his sense of logic, his ability to write and speak more concisely, introduce him to some of our historical heritage through its great contributors, and afford him an excellent opportunity to develop a better understanding and appreciation of the aesthetic. Judging from the majority of texts and objective outlines, this last point receives too little attention.

We all have a latent sense of line, proportion, etc. Else why do we feel annoyed when a wall picture is not straight? Our whole system responds to the "geometry" about us. Instinct guides us to the acceptance of certain lines and figures in preference to others. Why? Most of the answers can be cast in terms of pure geometric principles or theorems. Types of artistic problems which can be handled in a geometry class are the unit design with its study of symmetry, the border design, all-over patterns, root rectangles which the Greeks used in their art, cornices, and arches. This article will be limited to arches.

There are many types of arches, some are subheads under a general type, others are crosses between two distinct types. Let us consider the fundamental forms only. When, where, by whom, and why did each originate?

The lintel (not a true arch) (Fig. 1) could be constructed in ancient times only where there were local deposits of large pieces of granite or marble. The Egyptians, Incas, Persians, and Greeks employed this structure. In Egypt the Temple of Karnak (3000 B.C.) is an example. The Babylonians, Assyrians, Romans, and many others had to resort to other means of building their entrances. The Babylonians were among the first to build the semi-circular arch (Fig. 2). It was made of baked bricks. From west Asia, the semicircular arch traveled to Rome where it was used so extensively and exclusively that it became known as the Roman arch. Nature was kind to the Romans, giving them a


1 Lintel
2 Roman or Semi-circular
3 Stilted Semi-circular
4 Segmental
5 Venetian
6 Rounded Trefoil
7 Trifoliated Roman
8 Florentine
9 Equilateral Gothic
10 Drop Arch
11 Lancet
12 Pointed Horseshoe
13 Window Tracery
14 Italian Pointed
15 Round Horseshoe
16 Pointed Saracenic
17 Tudor
18 Colonial
19 Byzantine Trefoil
20 Ogee
21 Multifoil
22 Tracery
23
24

combination of lime and sand which produced a fine grade of brick. Their vaults were not surpassed until the present day of steel construction. Considering the fact that the Roman Empire flourished from the fifth century B.C. till the fifth century A.D., this is no mean accomplishment. Their windows were generally semicircular, sometimes segmental (Fig. 4). The tiers of arches of the Colosseum (A.D. 70) and the Pont du Gard at Nimes (19 B.C.) are splendid examples.

Byzantine architecture originated in and about Istanbul, the Byzantium of old. This fifth century architecture is now the style of the Eastern or Greek church. We find no Gothic spires or vaulted roofs here, rather, domes and minarets. The segmental, horseshoe (Fig. 15), ogee (Fig. 20), and semicircular arches are typical. The Saracens because of their wars of conquest absorbed some of the features of Byzantine construction, added elements of their own, and they and their descendents have spread their influence from India, through western Asia, across northern Africa, and into Spain. The horseshoe arch was brought to Spain by the Moors. Note the Alhambra with its foiled and horseshoe arches. This is the most famous of all Saracenic architecture and is exquisite in detail.

Among the most beautiful structures standing today are the cathedrals of northwest Europe and England. From the thirteenth until the sixteenth century religious enthusiasm gave impetus to this Medieval architecture, made possible by the wealth and power of the clergy. These cathedrals were made sacred against attack so they stand today in whole or in part. The Gothic arch (Fig. 9, 10, and 11) was the predominant arch used in these structures. Why? Many of the cathedrals were built on the plan of the Latin cross, a nave perpendicular to trancepts. When two semicircular vaults of equal span cross each other at right angles, the four groin lines are straight as seen from below (Fig. 24a). If one vault is narrower, it must be stilted (Fig. 3) to reach the height of the other, producing wavy groin lines (Fig. 24b). To avoid this the wider span can be dropped into an elliptical form. An easier solution is the pointed vault. This suggestion may have come from the pointed arch left in southern France by the Saracens. The groin lines will be straight. Consequently, the pointed arch made its way to the entrances and windows of cathedrals. Since flying buttresses reduced the function of the walls from support of vaults and domes to enclosure purposes largely, great wall spaces were

given over to stained glass windows, some of the most beautiful in the world. Mullions and tracery of arcs and cusps break these large areas on which are pictured in color bible stories and the deeds of great men.

The Tudor arch (Fig. 17) oft called the English Gothic, is a misnomer. Its original home was Assyria, old Saracenic domes having been made by rotation of the Tudor arch on its vertical axis. But it is a natural outgrowth of the Gothic arch. During the Tudor period (A.D. 1485–1558) attention turned from ecclesiastical to domestic building. The Tudor architecture made lower ceilings possible. These Tudor structures, usually built of stone, were characterized by stained glass windows, massive oak paneling, balconies, and staircases. Many a campus of the United States can boast of buildings constructed in excellent Tudor style, leaded panes and all.

Coming down to more modern times, commerce and ideas are more fluid. The three centered or "elliptical" arch (Fig. 18) is more difficult to trace but it may have come from the French. Often called the Colonial arch, it can be found over many southern doorways. Towns like Natchez, Mississippi, bear evidence in some of their ante-bellum homes. There are great numbers in such New England towns as Deerfield, Massachusetts and Farmington, Connecticut bearing dates from the late fifteenth to the early nineteenth centuries.

Precisely, how can a geometry class study these arches to advantage? (1) Pupils can be required to construct the leading lines of the simpler and more fundamental forms, showing clearly the centers and points of contact. These might be duplicated by hectograph or constructed on the blackboard for them. If evidence of construction is erased, the assignment is more challenging. The theorem: "The line of centers of two tangent circles passes through the point of contact" and the partial converse are used many times. These theorems are responsible for the smoothness and grace of some of the arches. See points A, B, and C of figure 17. "A perpendicular to a tangent to a circle at its point of contact passes through the center of the circle" causes the lines of some of the arches to slide smoothly into the supporting piers (Fig. 2 versus 4). A suggested list of drawings the average pupil can manage are numbers 2, 4, 6, 9, 10, 11, 15, 17, 18, and 19. (2) Better students will find numbers, 5, 20, 22, and 23 intriguing. Number 22 is not difficult, but 23, simple upon first sight, is deceptive. A more general construction for 23

which can be applied to 9, 10, or 11 is as follows: Construct CD on the axis of symmetry equal to AB, the radius of the arcs. The perpendicular bisector of AD (A being the center of the arc) will determine with CD the center of the inscribed circle. Have the excellent students inscribe a circle in each of the Gothic arches and prove their constructions correct.

(3) Some of the books of the bibliography have beautiful cuts. Examination of pictures with their captions is very worthwhile. (4) Ask children to look for examples of these arches in local structures. (5) A bulletin board display of pictures found in publications, everything from newspapers to the National Geographic, has its rewards. (6) The task of identifying the portals and windows of some of the leading buildings of the world, such as the Taj Mahal, Paris Opera House, St. Peter's of Rome, Milan Cathedral, Notre Dame Cathedral of Paris, Westminster Abbey, the Colosseum, The Alhambra, the Durham Cathedral, and others makes a supplementary project of cultural worth. (7) A few may wish to construct a Gothic arch with tracery, such as figure 13. See Sykes: *Source Book of Problems for Geometry* for others. (8) Probably all should know a little about the history of arches. The facts given in this article are meagre, but possibly sufficient at this stage of the pupil's development. If a test is given over the historical aspect, it should be very lenient to avoid loss of enthusiasm. Here are some suggested questions: Answer four of the following:

1. In what part of the world are the following: The Temple of Karnak, The Colosseum, The Alhambra?
2. Mention one country or people which has used each of the following arches extensively: Tudor, Gothic, semicircular, and horseshoe.
3. Spain copied the large stained glass windows of northern Europe and later had to seal them up with stone. Why?
4. Why wasn't the lintel used by the Romans?
5. In what part of the world were the flying buttresses used extensively?
6. Which arch do you like best? Do you know why?

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GEORGE E. HAWKINS NEW MATHEMATICS EDITOR

George E. Hawkins replaces the late Charles A. Stone as one of our two editors in mathematics. Mr. Hawkins received the two-year diploma from the State Teacher's College at Charleston, Illinois and the B.S. and M.S. Degrees in mathematics from the University of Chicago. He also has done extensive graduate work in the Department of Education at the University of Chicago. From 1930 until 1941 he taught mathematics in the University High School at Chicago. At present he is Chairman of the Department of Mathematics in Lyons Township High School and Junior College at La Grange, Illinois.

Mr. Hawkins has been active in teachers' organizations for a number of years. He is a past president of the Men's Mathematics Club of Chicago and Metropolitan Area and a member of the National Council of Teachers of Mathematics. He has served in numerous capacities in the Central Association of Science and Mathematics Teachers and during the year 1944 held the office of vice-president. He is a co-author of *Living Mathematics*, a textbook in general mathematics for use in the ninth grade, published by Scott, Foresman and Company.

REPLICA GRATINGS FOR SCIENTIFIC RAINBOWS BETTER THAN ORIGINALS

Copies of diffraction gratings, glass or metal with closely spaced parallel lines ruled on it, used in many types of spectrographs, are even better than the original gratings from which they were made, Dr. R. W. Wood, the Johns Hopkins University physicist, has reported in the *Journal of the Optical Society of America*.

Coarse gratings of 1,000 to 7,000 lines to the inch, which are especially useful for analyzing infra-red light, are first ruled on copper plates which have been polished as well as possible but cannot be made as flat as polished glass.

The collodion cast or copy of the original grating will reproduce faithfully both the carefully ruled lines and the small irregularities of the surface of the copper plate. But when this replica is pressed into contact with a piece of optically flat plate glass, the imperfections on the surface are "ironed out," leaving the replica with better optical properties than the original.

Studies of light spectra with these gratings not only extend our knowledge of the behavior of atoms but also have practical applications such as the identification of impurities in chemicals or metals. Spectrographic analysis is one of the most powerful tools of modern physics.

Rainbows are spectra formed by raindrops which act somewhat as do the gratings.

THE ROLE OF THE SCIENCE OR MATHEMATICS TEACHER IN MEETING THE NEEDS OF THE VETERAN WHO RETURNS TO SCHOOL*

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Chicago Junior College

Before considering the ways in which science and mathematics teachers can help solve the educational problems of returning veterans, one must know the kinds of educational opportunities available to men and women in the armed forces.

While in the services men and women have three general types of opportunities for educational growth. All service personnel receive several weeks of basic training and approximately two-thirds receive some kind of specialized training. The emphasis in the specialized training programs has largely been in mathematics, physics, engineering, and other technical subjects. For example, the engineering curricula of the A.S.T.P. and the V-12 programs compare favorably with the engineering curricula of typical civilian engineering colleges and have been taught by instructors in such colleges. There is, of course, a considerable acceleration in such programs and although the students are highly motivated, it is probable that the effects of such training are not as well organized, completed, or integrated in the minds of the students as is the case after normal civilian instruction. It is also probable that veterans who have experienced such instruction and who return to engineering colleges after the war will be characterized by wide individual differences in ability. Later in this paper the problem of dealing with such individuals will be discussed.

Many men and women will grow intellectually as a result of the informal educative experiences of military life in various parts of the world. In practicing the skills for which they were trained, these men and women should develop still further these various technical abilities. Travel to various parts of the world may insure broader knowledge of geography and, in the case of interested individuals, experiences with plants and animals may make some contribution to their knowledge of biology.

The educational growth of the service man or woman need not be restricted to what is gained as a result of training or is secured informally. The operation of an extensive program of

* An address before the Junior College Group of the Central Association of Science and Mathematics Teachers, November 23, 1944.

off-duty education makes it possible for service men and women to continue educational careers interrupted by the war. The administration of this program of off-duty education is the major function of the United States Armed Forces Institute, an official agency of the Education Branch of the Army and of the Educational Services Section of the Navy.

After a period of careful planning participated in by civilian educators, the War Department authorized the establishment of the Army Institute in December, 1941. Headquarters were established in Madison, Wisconsin, in April, 1942. An Editorial Staff was organized in Washington and an Examinations Staff established at the University of Chicago. In July, 1943, the Army Institute became the United States Armed Forces Institute and its facilities were made available to any man or woman in the Army, the Navy, the Marine Corps, or the Coast Guard. The facilities of the Institute are offered from the Headquarters at Madison, or from branches of the Institute established in key centers throughout the world.

Beginning in 1942, the Institute has offered sixty-four correspondence courses largely on the high school level and, in cooperation with eighty-one colleges and universities, seven hundred courses on the college level. A fee of two dollars has been charged for the first enrollment in a correspondence course offered directly by the Institute. No additional fee has been charged for courses of this type as long as the student remains in good standing. In the case of the college or university correspondence courses, the government pays half the fee charged by the cooperating institution up to a limit of twenty dollars per course.

The offerings just described are those which were made immediately available. Through the efforts of the Editorial Staff of the Institute and with the cooperation of numerous textbook authors and textbook publishers, the curriculum of the Institute has been greatly expanded beyond the original offerings. The new catalog of the Institute lists almost three hundred courses classified under the headings of aviation and automotive; building construction; business administration; drafting and applied art; education and psychology; electricity, electronics, and radio; English and journalism; foreign languages; history, government, and sociology; marine engineering; mathematics; mechanics and engineering; metal working; photography; plastics; railways and transportation; and science. The mathematics

courses range from elementary arithmetic through calculus and differential equations. The science courses include general science, inorganic chemistry, physics, electricity, and general geology. Among the many engineering courses are the following taken at random from the various lists: air conditioning; details of concrete structures; theory and construction of electrical machines; strength of materials; metallurgy and heat treatment; railway track maintenance.

Many of the new courses listed are correspondence courses obtained by the Institute from the extension divisions of various colleges and universities. These are now available on the basis of the single two-dollar fee. A number of the courses are of the self-study or self-teaching type published as inexpensive paper bound texts and accompanied by practice or work books. (Correspondence lessons may be provided for many of these courses.) The self-study text and the work book may be used either by the individual, or they may be used as the basis of class or group instruction. Detailed teaching plans are being developed for many of these subjects to assist the group leader or teacher. It is expected that group, or class, instruction will greatly expand as more and more territory liberated from the enemy is occupied by our forces. Group instruction should be both popular and successful during the periods of occupation of conquered territory and of demobilization. It is expected that the entire off-duty educational program will be an important means of maintaining morale and of preparing service men and women for return to civil life.

The preceding discussion has been concerned with the types of educational opportunities available to men and women in the armed forces. With this description as a basis we can turn now to the problems of the returning veteran and the ways in which science and mathematics teachers can aid in their solution. The problems may be conveniently classified under three heads: (1) evaluation of abilities, (2) placement in terms of abilities evaluated; and (3) provision of remedial or supplementary instruction.

The evaluation of abilities of returning veterans may be accomplished in two general ways. If the veteran has had basic and/or specialized training, some estimate of the abilities acquired by the veteran may be obtained by examining his record in relation to information presented in the Handbook on the Cooperative Study of Military Training and Experience being

prepared under the direction of Mr. George Tuttle and his staff at the University of Illinois. This handbook will describe the various training courses and will make recommendations with respect to credits which may safely be awarded. Further evidence of ability may be obtained by the administration to returning veterans of the relevant subject tests of the United States Armed Forces Institute. These tests will be available in all of the more popular high school and college subjects. The tests have been standardized on populations of civilian students. They may be obtained from the Headquarters of the Armed Forces Institute by schools or colleges meeting certain requirements, or they may be purchased from the Cooperative Test Service. The tests may be administered to veterans whose specialized training would seem to require such evaluation or they may be administered to veterans who have had Institute courses. While the best estimates of ability may be made through use of the subject tests, since these have been standardized in terms of ordinary students, other estimates may be made on the basis of the end-of-course tests administered to veterans while in the service. The end-of-course tests are administered on completion of the self-study or correspondence courses and the results reported by the Institute to interested schools or colleges. While these tests have been carefully constructed and are rigorously administered, they have not been standardized on the basis of populations of civilian students.

It is highly recommended that science and mathematics teachers become familiar with the subject tests of the Institute which may be obtained from the Cooperative Test Service. Use of these tests by such teachers with ordinary classes should serve to establish local norms and thus promote more adequate evaluation of the abilities of returning veterans.

In addition to the subject tests there are also available the Armed Forces Institute Tests of General Educational Development. These include on the high school level (1) English Expression, (2) Interpretation of Social Science Materials, (3) Interpretation of Natural Science Materials, (4) Interpretation of Literary Materials, and (5) General Mathematics. The battery on the college level is similar in character, except that there is no test in general mathematical ability. The subject tests in college algebra, trigonometry, or analytical geometry may be substituted. These tests will be very useful in securing a general pattern of the ability of the student. The test entitled "Interpre-

tation of Natural Science Materials" includes several selections drawn from various natural science fields. The student reads these selections and responds to carefully constructed objective exercises pertaining to them. They are not simply reading tests since to respond successfully to the exercises the student must also possess knowledge of the subject matter involved.

Evaluation of abilities need not be restricted to estimates based upon records of training nor to scores on Armed Forces Institute tests. Many schools are devising their own programs of evaluation and testing. Through interviews much can be learned which will be useful in the appropriate placement of veterans. It must be emphasized that the science or mathematics teacher should participate in the evaluating. Questions of credit and placement on the basis of credit cannot be left entirely to the administrative officers of schools and colleges. Registrars and personnel directors will have the chief responsibilities in setting up adequate programs of evaluation for the sake of credit and placement. They will have the major responsibility in organizing counseling so that the returning veteran may be aided in selecting courses compatible with his training and other educative experiences. The registrars will need and welcome the help of teachers in the various subject matter fields in evaluating the abilities of the veteran, in determining his appropriate placement, in counseling him in the selection of courses, and in following up decisions made at the time of his entrance in the school to see that he has become adequately adjusted.

Some mention has already been made of the part the science or mathematics teacher can play in helping to secure appropriate placement of veterans. There is more that these teachers must do. Evaluation of abilities will disclose much greater individual differences than is characteristic of students who have been subjected without interruption to traditional courses of study in civilian high schools and colleges. There will be great variation from veteran to veteran even though backgrounds of basic and specialized training are apparently the same. There will be great variation among the veterans in patterns of abilities. Many will know certain advanced aspects of science or mathematics and yet not possess information basic to these fields. Adequate placement of such persons may require the formulation of course programs which would appear extraordinary under other circumstances. Advanced abilities in certain restricted areas will necessitate provision of further education

on the same level if the individual is to be challenged by his instruction. Unless the veteran who possesses highly specialized abilities is given the opportunity to continue on a mature level he is likely to feel that school has not much to offer him. He will also need to be stimulated to obtain the basic knowledge he may have missed. Adequate placement will often mean the selection of appropriate courses on several different levels.

While many of the problems of placement may be solved by careful selection of courses included among the usual offerings of a high school or college, there will be many veterans whose problems cannot be solved in this way. For example, there will be those who seek entrance to college without graduation from high school. Many of these men may be potentially able to carry on college work. Their scores on the tests of General Educational Development may reveal intellectual maturity well beyond that of the typical high school graduate. They may lack, however, basic knowledge which will need to be provided. Some colleges and universities are planning to offer high school level courses to veterans admitted as college students who need such courses as prerequisites for more advanced instruction. Teachers of advanced courses may aid in the solution of this problem by determining the minimal amounts of prerequisite knowledge which must be provided.

One of the most practical ways in which the science or mathematics teacher can help the veteran is to make provision for supplementary or remedial instruction for veterans enrolled in ordinary classes. Extended explanations of subject matter and supplementary assignments may be effective ways to give the veteran the means of holding his own with other members of a class. The use of such techniques will require discretion, since the veteran will resent coddling.

In the conclusion of this discussion of the ways in which the science or mathematics teacher can aid in the solution of the problems of returning veterans, certain points may be repeated for the sake of emphasis. Veterans will vary greatly in ability. Within the individual there will be great variations in patterns of ability. Science and mathematics teachers should cooperate with registrars and personnel directors in securing adequate evaluations of ability, in counseling students on the basis of such evaluations, in formulating programs of courses in terms of individual needs, and in providing supplementary or remedial instruction where necessary.

CAN SCIENCE COURSES BE TAUGHT SCIENTIFICALLY?

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Now that everybody is concerned with postwar planning we naturally turn our attentions to the challenge of doing a better job of teaching science. Critical reflective analysis of our courses indicates that many of us are victims of the "traditional approach" to the teaching of exact sciences. Our sequence of presentation of subject matter, as outlined in current secondary school tests shows an amazing similarity. With few exceptions approved texts follow an order of presentation that has been in mode for at least twenty years. In light of rapid advances in the field of science teaching, such strict adherence to an established routine smacks of an Aristotelian influence.

There may have been a time when it was possible to teach students the sum total of all scientific knowledge. Apparently, with some this is still an objective. Publishers extol the virtues of their texts by indicating that they contain paragraphs on the very latest contributions of science. Teachers' conventions are often characterized by discussions on how to include new topics in an already overstuffed text.

To hear the problem argued incessantly would be amusing if it didn't have such harmful results. Due to the large body of information which is being added to an already swollen list of "minimum essentials," we are constantly cramping our methods of presentation. If this is carried on indefinitely, one can visualize a situation where it will become necessary for the teacher to start lecturing at the start of a classroom period, and shunning all interruptions, continue until the bell.

A fair criticism of our present courses is that they are too nearly limited to a "giving back" by students of information which we, or our textbook writers, deem essential. Many times we fail to distinguish between learning and memorizing. As proof of this assertion, examine some of our tests, quiz questions, and examinations.

Laboratory work is a weak spot in our teaching. Our laboratory is not made a place for student discovery, but for repetition of exercises of predetermined nature. Modern educators believe in permitting the student to do some problem-solving, allowing

him to have a part in setting up the procedure, and in drawing his own conclusions.

Outside reading assignments are another weak spot. Too many of our libraries are inadequate. Their material is dated. They possess too few copies of books from which extra assignments can be made. In short, they contain too little information on many topics to make the trip to the library worthwhile. This is a very discouraging fact to interested students, and an alibi for others.

In discussing opportunities for postwar education, we ought to reaffirm our aims and objectives in science teaching. I don't think there would be much argument in stating that one of our primary objectives would be the development of a scientific attitude in students. As a result of this attitude we would like students to transfer use of this tool to many areas of living experience. We seek to develop an inquisitive mind, so the student will wonder, and seek knowledge. We accomplish this by using a body of facts known as chemistry, or physics, or some other science. In this way, students learn to employ principles, laws, theories, and facts to answer questions.

Examined in the light of these objectives, the style of presentation of our present texts seems inadequate. This is true as to the nature of material they present as well as to the method of presentation. I have discovered no single textbook written with this approach in mind. What we are seeking is an inductive approach to the teaching of science, and to date this need remains unfilled. Subject matter organization is unreal. Chromium, The Lighter Metals, Osmosis, and Wheatstone's Bridge have no significance as topic headings to the uninitiated. The text should be written to solve real problems. Such topics as "What Makes Things Rust?", "What Makes a Refrigerator Work?", "What is Paint?", and others of this nature serve to illustrate an approach that stimulates thinking—the first step in the development of a scientific attitude. Similarly, our laboratory work does not teach scientific thinking. Too many questions can be answered by implication, or by reading; too few opportunities are given students for drawing conclusions. Too little experience is provided in setting up their own experiments, and in solving their own problems.

Teaching for these objectives is hard. It is much easier to follow the traditional pattern. Yet, only part of the blame for failure to use our knowledge of modern teaching objectives is due to the teacher.

In practicing scientific thinking in classrooms and laboratories the amount of subject matter would suffer greatly. From present indications it is questionable whether colleges would be satisfied. For this reason is is unfortunately true that some of our most modern teaching has been done in classes reserved for the so-called "dumbbells."

This kind of teaching demands individual instruction. Mass production in classrooms is conducive to regimentation, not creativity. The implication is small classes, much smaller. We must also have different physical arrangements in classrooms. Fixed seats limit breaking up into small interest groups. The laboratories must be more readily available, so that some can work there until they complete what they are doing. Interest, like matter, cannot be created or destroyed, at the sound of a bell. A great deal is lost by interrupting an experiment amongst a group of interested students on Tuesday, and expecting them to be equally interested on the following Monday. The environment must be informal, and conducive to work when the interest is there.

Since much interest is derived from newspapers, magazines, and similar sources, a good filing cabinet must be accessible. Why this hasn't been made a recognized part of the equipment of all classrooms is hard to know. A good library, including vocational books, reference books, supplementary texts, booklets, samples of materials, etc. is needed. Also necessary is functional information on student's interests, training, aspirations, home situation, and other pertinent data. The teacher must be trained in stimulation and motivation. He must be allowed sufficient time outside of regular class work for preparation and study. Under proper conditions we can more easily translate our scientific thinking into scientific action.

Another question is involved. Will the public pay for such instruction? I do not believe so. I do not think they know that we want such methods, and that we believe such methods to be superior. Our public relations people have to get busy. They have a job of selling to do. Education is guilty of the mistake common to many public organizations. It keeps telling the public what a fine job we are doing, but fails to point out at the same time how badly we need new equipment, new buildings, smaller classes, and more teachers to do an even better job. These facts are kept as "trade secrets." Until the public is convinced of our need for these things, the practical conversion of

all our schools to well known progressive education methods will remain a worthy subject for talk, not action.

The items mentioned above can come under the head of *long range planning*. There are, fortunately, some things which we can do that can be classified as *items for immediate action*. First, much can be accomplished with our present set-up in the area of individualizing our instruction. One of our basic weaknesses is that we are not set up to learn the present status of pupil knowledge. Through the medium of personal interviews much can be accomplished, if we take the time. We need to develop, also, a questionnaire on their interests, scientific background, mathematics background, study conditions, home conditions, and abilities. By graduating requirements for different grades of students, we can more nearly fit the course to their needs. This applies to the daily assignments, special work, individual laboratory experiences, gauging tests to abilities, and the liberal use of projects. Allowing student participation in the planning of the courses each time, is another forward move.

Postwar planning would indicate the need for fuller utilization of modern teaching tools by a greater number. Our classrooms and school libraries can be expanded by the addition of printed information and materials obtained from government sources, industry, educational institutions, professional organizations, and magazines. Visual aids and equipment are in need of modernization; then more widespread use of them should be made. We haven't taken full advantage of our friends in the community who are willing to come into the schools to describe their industries and interests, and who are also willing that we return the visit to their laboratories and plants. In the matter of testing, we are woefully weak in taking advantage of modern techniques. We should work out our own tests, or know where we can get printed ones that measure more easily and more positively. We should also strive to measure more than subject matter.

Now seems an appropriate time to go over our equipment and material lists, and to bring into the laboratory more modern materials and equipment. Study needs to be given to the development of effective classroom demonstration materials, and to methods of storing and handling them. This will avoid tremendous waste of time and effort in making them ready for use.

There is a need for a well developed set of charts, outlines, sample displays, and models to make instruction more effective.

A correlation of ideas of individual teachers and professional organizations to produce this material seems in order now.

Radio programs have not yet assumed their important place in our teaching. Not enough science programs have been developed. Those programs offered on the regular commercial networks must be recorded, not gotten directly over the P.A. system or the school radio. Administrative difficulties make it likely that many of these fine broadcasts are completely missed. Further, there are not enough of these programs broadcast. The schools should serve as the leaders in developing a library of scientific recordings as a new and useful teaching tool.

Teachers must learn to use the large body of facts and tools of psychology. These could help modernize classroom teaching. Fuller use of our laboratories to test and debunk so called "miracles," and "amazing new discoveries" is in order. These could be utilized as tools in teaching scientific attitudes and scientific method.

AMERICAN SCIENTIST GOES TO CHILE TO AID IN CREATION OF BRAND-NEW NATIONAL RESOURCE THROUGH PROTECTION OF SEA BIRDS

Creation of a brand-new economic resource for Chile, where nothing of its kind now exists, is the errand that is taking William Vogt, chief of the conservation section of the Pan-American Union, southward to our neighbor republic. Mr. Vogt has just left Washington, and will be in Chile until early in February.

Guano, natural fertilizer especially rich in nitrogen, is the new resource for Chile that is expected to result from work to be done under Mr. Vogt's direction. Guano accumulates on off-shore islands where swarms of fish-eating sea birds nest, if there are enough of them and they are not disturbed too much.

Chile has the islands—hundreds of them. The islands have bird populations, mainly pelicans, cormorants and boobies. But in the past they have been consistently raided by unregulated collectors of eggs for the market, as well as the bodies of the birds themselves. Hence their populations have not grown to the point of profitable guano production; or on the few islands where any accumulation has taken place, again unregulated exploitation has removed it before they have been any really profitable quantities.

Conservation measures aiming at the increase of island bird populations include protection of the birds and their eggs against commercial "birders" and "eggers," inducing ships' officers not to sound their whistles so close as to scare the birds off their eggs, and keeping low-flying aviators away for the same reason.

Timing of legitimate guano collection is also of importance. It must not be carried on during the nesting season, lest the birds desert their eggs and thereby reduce the number of feathered "workers." In the past, thoughtless guano diggers have even assigned men the job of driving off the birds, so that they could carry on their work undisturbed!

A SIMPLIFIED METHOD FOR THE DETERMINATION OF ANALYTICAL GROUPS IV AND V

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Most courses in qualitative analysis for beginners use the wet method for the determination of the alkali and alkaline earth metal ions. This is regrettable, since the spectroscopical method is not only speedier, but also more precise and of higher practical value (1). Further advantages of the spectroscopical method are the opportunity to make the student familiar in the use of the fundamentals of an important technique and the possibility of using this familiarity to advantage in the teaching of atomic structure. (See for instance P. Swing (2), H. G. Deming (3) and others.)

The writer has used the following method for a number of years. It avoids the determination of wave lengths and can therefore be used without preliminary work on the instrument. The complete analysis of the common ions of groups IV and V is carried out by the beginner in 10 to 15 minutes. The number of student analyses which had to be rejected was negligibly small (approximately 3%).

Requirements

Spectroscope: Simple instruments gave the best results. The field of vision is chosen or screened, so that only the wave lengths from 4500 to 6800 A.U. can be observed (in order to avoid mistaking the red K-line for Li and the blue Ca-line for Sr).

Pt-wire: 1″ to 1½″, mounted in a glass rod which carried a rubber stopper and kept in a glass tube containing 5 ml HCl dil. 1:1.

Co-glass: It proved advisable to use two or three thicknesses of the commercially available Co-glass. The slides may be fastened to each other by the use of scotch tape around their edges.

Preparation of the Unknown

The acidified solution containing groups IV and V only, or the filtrate from group III (in the case of absence of phosphoric or oxalic acid) or the combined filtrates from group III (in the case of presence of phosphoric and/or oxalic acid) are made up—or taken down—to 5 ml, which are preferably placed into a test tube of the same kind as is used to house the Pt-wire. The hot wire can then be dipped into the unknown, while the rubber stopper prevents damaging contact of the liquid and the heated glass rod.

The Analytical Procedure

The following four steps are carried out:
1. Determination of the coloration of the flame by the unknown.
2. Determination of the color of the flame through the Co-glass.
3. Observation of the colored flame through the spectroscope.
4. Determination of Mg^{++} by the wet method.

The reactions of the ions during the first three steps are given in the following chart. The underlined reactions indicate the presence of the ion in consideration and are immediately recorded as such.

Ion	1.) Flame test	2.) Flame through Co-glass	3.) Flame through spectroscope
Li^+	red	unchanged	red line
Na^+	bright yellow for at least 3 seconds	unchanged	yellow line
K^+	purple	purple	unchanged
Ca^{++}	Orange, the last color to appear	unchanged	orange bands
Sr^{++}	red	unchanged	orange bands and blue line
Ba^{++}	green for some time	unchanged	orange and green bands

Determination of Mg^{++}

Part of the solution which has been used for the spectroscopical test neutralized by NH_4OH and an excess of Na_2HPO_4 is added. The solution is then separated from the precipitate. The precipitate is washed with distilled water, then covered by distilled water and several drops of p-nitro-benzene-azoresorcinol (1.2 g in 240 ml alcohol) added. Dilute NaOH is added drop by drop till the turning point of the indicator is reached. A blue lake is formed by Mg^{++}.

References

1. E. H. Swift: A system of chemical analysis. Prentice Hall, 1939, page VII.
2. P. Swing: La spectroscopie appliquée. G. Thone, Liège, 1935.
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RUSSIAN EXPEDITION TO STUDY COSMIC RAYS IN PAMIR MOUNTAINS

A group of scientists from the Lebedev Institute of Physics of the U.S.S.R. Academy of Sciences has left for the Pamir Mountains to study cosmic rays at high altitudes. The expedition, under the direction of Prof. D. V. Smobeltsyn, will continue studies that have been carried on for several years at the Atomic Nucleus Laboratory on Mount Elbrus, the highest mountain in the Caucasus. The Pamir Mountains are located in southern Russia, where they reach into both Afghanistan and India.

Main objective of the expedition is to study the composition of cosmic radiations at high altitudes and determine the role played by heavy particles and secondary mesons first discovered in cosmic radiations in 1937.

In conducting its studies, the expedition will make use of a perfected proportional telescope and improved methods which the Atomic Nucleus laboratory has developed.

THE ALGEBRAIC NUMBER SCALE

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An arithmetic number scale with zero at the left and the numbers 1, 2, 3 . . . extending at equal intervals to the right could very well be a familiar concept to students beginning the study of Algebra.[1]

Assuming an arithmetic scale marked off conveniently in 5's, let us consider the problem,

$$50-15+30-30=?, \tag{1}$$

which signifies that starting with 50 we are to subtract 15, add 30, and subtract 30.

We can visualize these operations by observing the motion of a representative point which, located initially at 50, moves leftward 15 spaces to 35, then to the right 30 spaces to 65, and finally leftward 30 spaces back to 35.

Subtractions and additions evidently effect leftward and rightward displacements upon the representative point. To picture these two kinds of movement graphically we are led to adopt, in addition to the arithmetic scale, a new 2-way displacement scale in which line segments measured in two directions from an origin depict the right and left effects of addition and subtraction respectively.

With the addition of scale numbers to the right and to the left of the origin, the displacement scale is complete and adequate for the purpose suggested. It would be convenient, however, to have a method for distinguishing the two sets of numbers.

We might, for example, place primes on the numbers to the right and leave those on the left unprimed—or, we could make the numbers to the left red and those on the right blue (or black).[2]

In contrast with the scheme involving primes which has no connotative value, the device selected is the most perfect memoria technica imaginable for recalling the additions and subtractions of eq. (1). This device consists in prefixing the

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[1] With two such scales addition and subtraction become purely mechanical procedures. To add 4 to 3 e.g., place the zero point of the second scale upon the 3 mark of the first. The sum is read from the point in the first scale which is coincident with the point marked 4 on the second scale. Subtraction is effected in a similar fashion.

[2] Red and black with its bookkeeping connotation of debit and credit which in turn suggests addition and subtraction, would add color and economy in writing.

operational + and − signs of eq. (1) as *labels*, to the right and left scale numbers as in the figure below.

$$-4 \quad -3 \quad -2 \quad -1 \quad 0 \quad +1 \quad +2 \quad +3 \quad +4$$

The fact that it is not generally recognized as a "device" is eloquent testimony to its compelling appropriateness.

It is also evident that the + or − label serves not merely as an effective memory device but taken together with the corresponding scale number it constitutes a single, unitary thing which is ideally suited to serve as an abstract symbol for the directed displacement segment to which it corresponds.

It would be appropriate, therefore, to refer to it as a displacement number. But since it is essential to "keep the signs straight" and since the displacement idea is conveyed by the context such a number is more effectively described as a ***signed*** number. Thus we speak of $+3$ (plus 3) and -5 (minus 5).[3]

We proceed to rewrite eq. (1) in terms of the displacement scale. Marking the points -15, $+30$, -30 constitutes a memorandum for recalling the direction and extent of the right and left (add and subtract) displacements to be effected upon the representative point which is placed initially at 50 on the arithmetic scale. In place of eq. (1) we have, therefore,

$$(2) \qquad \begin{array}{ll} 50 & \text{on arithmetic scale,} \\ -15+30-30=-15 & \text{displacement numbers.} \end{array}$$

The displacements $+30$ and -30 cancel each other leaving a net leftward displacement of -15.[4]

Interpreted on the arithmetic scale this signifies that the representative point is to be shifted leftward 15 spaces from 50 to 35. This is accomplished by superposing the two scales so that the representative point which is located at 50 on the arithmetic scale coincides with the zero of the displacement scale. When this is done the result of the operations indicated by eq. (1) or its equivalent, eqs. (2), is the arithmetic number 35 which coincides with -15 on the displacement scale.

[3] In eq. (1) the + and − signs indicate operational relations and are therefore written *between* the numbers concerned. On the displacement scale their very different role as descriptive labels is emphasized by placing them as closely as possible to the corresponding scale numbers.

The impetus toward thinking in terms of signed numbers which results from this close coupling of sign and number is a striking illustration of the fact that a change in notation may lead to a revolutionary change in thinking.

[4] With oppositely directed displacements which are unequal such as $+40$ and -25, the obvious procedure is to separate $+40$ into $+15+25$ and then cancel $+25$ with -25, which leaves $+15$. Since 15 is the difference of the numerical values we obtain the usual rule, to combine numbers of unlike sign subtract the smaller from the larger and prefix the sign of the larger.

The canceling procedure might seem to constitute the essential merit of the 2-way scale. But with $+30$ and -30 canceling is just as effective in terms of eq. (1) on the ground that the addition and subtraction of 30 are canceling operations. On the other hand additions and subtractions which are not successive and possibly unequal in numerical value would offer more difficulty from the arithmetic point of view. For such cases the displacement scale would be distinctly helpful.

The really significant merit of the displacement scale lies, however, in the fact that the dispassionate recording of additions and subtractions independently of each other leads inevitably to a bookkeeping point of view in which there is no inhibition about recording subtractions which outweigh the additions.

Up to this point the numerical value 50 has enjoyed a status which is unique in that each of the numerical values of eq. (1) *with the exception of 50* is preceded by a $+$ or $-$ sign.[5] Thus 15 is preceded by a $-$ sign and we think of it as a number which is to be subtracted. In like fashion the 30's are to be added, or subtracted, depending upon whether the preceding sign is $+$ or $-$.

Evidently 50 is not regarded as a number which is to be added to or subtracted from any other number. Its role is to serve "passively" as an initial minuend. Eq. (2) gives recognition to this point of view by placing the representative point at 50 on the arithmetic scale. On the other hand, in terms of the final result it is evident that 50 plays exactly the same role as the numerical value 30 which is preceded by a $+$ sign.[6]

We may, however, think of 50 as a number which is to be added to zero. Adopting this point of view we assign to zero the minuend role which was formerly held by the 50, and eq. (1) takes the form,

$$0+50-15+30-30=?. \tag{3}$$

From the displacement number point of view, we now start with the representative point initially at zero on the arithmetic

[5] In textbooks on algebra it is standard practice to take it for granted that a is identical with $+a$. To motivate this identification is the aim of the following discussion.

[6] We have employed this awkward phrase in place of the briefer $+30$ because for the moment we are thinking in terms of eq. (1). The circumlocution serves to call attention to the unwieldiness of arithmetic terminology in the present connection. On the other hand speaking of 15, as we did above, apart from its minuend, as a number to be subtracted represents a shift toward the signed number point of view.

scale and record an additional rightward displacement of +50 on the displacement scale. In place of eq. (2) we have therefore,

$$(4)\qquad \begin{array}{ll} 0 & \text{on arithmetic scale,} \\ +50-15+30-30=+35 & \text{displacement numbers.} \end{array}$$

+30 and −30 cancel as before. +50 may be replaced by +35 and a +15 which is canceled by −15, leaving a net rightward displacement of +35.

Transferring +35 to the arithmetic scale is simplified by the fact that on the basis of the first of equations (4) the two scales are superposed with their *zero points coincident.*

The final result as read on the arithmetic scale is therefore 35 and it is evident that in like manner any net displacement $+a$ leads to the numerical value a on the arithmetic scale.

Since the substitution of eq. (4) for eq. (2) has led to this very considerable simplification we are encouraged to go one step further, eliminate the arithmetic scale entirely and simply give to any net $+a$ the reading a which it would have if it were transferred to the arithmetic scale.[7]

The really significant gain in eliminating the arithmetic scale appears however in connection with an "untransferrable" net leftward displacement number. Suppose e.g. that in eq. (1) we have another subtraction of 40. In eq. (4) this would mean another displacement of −40 which leads to a net displacement of −5. If we recall that in the present arrangement the representative point of the arithmetic scale is placed initially at zero it is evident that a displacement of −5 would mean a movement to the left of the origin. Since the arithmetic scale extends only to the right it is clear that the contemplated displacement is impossible and meaningless.

To remove this difficulty, we effect a "strategic" retreat and desisting from any attempt to transfer −5 to the arithmetic scale; we simply leave it where it is on the left half of the displacement scale. If, now, we eliminate the arithmetic scale the effect is to give the untransferrable −5 the same numerical status as the transferrable +35 of eq. (4).

To state the situation in another way, +35 and −5 are poles apart, in terms of the arithmetic scale, because they represent operations which are performable and unperformable respectively. But since the 2-way displacement scale is essentially a

[7] This completes the identification of + numbers with the unsigned arithmetic numbers.

memorandum device for indicating operations which are to be performed regardless of whether or not they can actually be effected in the arithmetic sense it is evident that in terms of this scale $+35$ and -5 have identically the same status as potential or pending operations.[8]

The left and right halves of the displacement scale are therefore the graphical equivalents of the debit and credit columns which are essential to the bookkeeping structure of algebra.

[8] Recalling Koko's remark in Gilbert and Sullivan's Mikado, "When your Majesty says 'let a thing be done' . . . practically, it is done."

POST-WAR AVIATION

Orders for 93 new high-speed, four-engined air liners were placed with the Douglas Aircraft company by three of the world's largest airlines at a meeting in New York City in September.

Signing of the contracts marked the first large-scale, concerted move to provide domestic and international airways with sky giants in the immediate post-war period.

The total cost of the planes will exceed $50,000,000.

The contracts were placed by American Airlines, Pan American-Grace and United Air Lines. They called for delivery of 25 Douglas DC-4's and 30 Douglas DC-6's to American; three DC-6's to Pan American-Grace; and 15 DC-4's plus 20 DC-6's to United.

Under discussion, but not ready for signature, are additional contracts with Eastern Airlines, one of the original four lines which had these planes on order before the war, and other large operators in the United States and abroad.

United Air Lines announced that within a week it would sign contracts for an additional 15 DC-6's, making a total of 50 four-engined planes in all for this company.

This will make the total to be placed into production by Douglas in excess in 100.

THOMAS MIDGLEY, INDUSTRIAL CHEMIST

The tragic accidental death of Thomas Midgley, eminent industrial chemist, robbed the United States of one of the most fertile of its array of scientific minds. Among Mr. Midgley's best known accomplishments were the discovery of tetra-ethyl-leaded gasoline, which has gone far to make this country supreme in both aircraft and automotive power, and freon, which is used both as a non-inflammable, non-poisonous refrigerator fluid and a carrier for insecticides in the mist-spreading "bombs" now used on all the world's battlefronts to keep death-carrying mosquitoes and flies in check.

Mr. Midgley participated, back in World War I days, in researches that produced a pioneer-model robot bomber—which never saw action because it was completed only a little while before the 1918 armistice. However, it did successfully hit targets after test flights of as much as 35 miles.

Indefatigable in his pursuit of research and executive work despite a crippling attack of infantile paralysis a few years ago, Mr. Midgley presided at meetings of the American Chemical Society in a wheel chair and maintained nation-wide contacts with his colleagues via long-distance telephone.

SUBJECTS TAUGHT BY SCIENCE TEACHERS IN THIRD CLASS SCHOOL DISTRICTS OF PENNSYLVANIA

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Introduction

This study is a segment of a study of teaching combinations in junior and senior high schools located in third class school districts of Pennsylvania. In Pennsylvania, school districts with a population of 5,000 or more persons but less than 30,000 persons are considered third class school districts. The median population of the third class school districts studied was 10,080.

Questionnaires were submitted to junior and senior high school principals requesting that the subjects taught by each teacher individually during the 1943–1944 school year be listed on the questionnaire.

The study was undertaken for the purpose of ascertaining the subjects taught by science teachers in the third class school districts of Pennsylvania and to discover information of value to be used in the guidance of students preparing to teach science in those districts.

The total number of teachers listed on the usable questionnaires returned was 4,618. Of this total number, 607 or 13.14 per cent of the junior and senior high school teachers were teaching science.

Biology was taught by 217 teachers or 35.75 per cent of the science teachers. 156 teachers or 25.70 per cent of the science teachers were scheduled to teach chemistry. General science was taught by 282 teachers or 46.46 per cent of the science teachers. Various sciences, such as junior science, related science, practical science, senior science, intermediate science, and industrial science, closely allied to general science was taught by 77 teachers or 12.68 per cent of the science teachers. Therefore, 359 teachers or 59.14 per cent of the science teachers were teaching general science or sciences closely allied to general science. Physics was taught by 149 teachers of 24.55 per cent of the science teachers.

In order to show the extent to which wartime courses, such as fundamentals of machines, fundamentals of electricity, aeronautics, and radio, were being taught by science teachers, these courses were treated as separate subjects in this study.

TABLE I. COMBINATIONS TAUGHT BY BIOLOGY TEACHERS

Biology	65
Biology, General Science	47
Biology, Chemistry	17
Biology, Social Studies	10
Biology, Mathematics	7
Biology, Physics	5
Biology, Health and Physical Education	4
Biology, English	4
Biology, Aeronautics	3
Biology, Senior Science	3
Biology, Home Economics	2
Biology, Guidance	2
Biology, Functional Science	1
Biology, Spelling	1
Biology, Commercial	1
Biology, Blue Print Reading	1
Biology, Radio	1
Biology, Manual Arts	1
Biology, French	1
Biology, Conservation	1
Biology, Practical Science	1
Biology, Fundamentals of Machines	1
Biology, Related Science	1
Biology, Chemistry, Physics	6
Biology, General Science, Mathematics	2
Biology, Chemistry, General Science	2
Biology, Health and Physical Education, Senior Science	2
Biology, English, Latin	2
Biology, General Science, Latin	1
Biology, Library, Social Studies	1
Biology, Chemistry, Geography	1
Biology, Chemistry, Mathematics	1
Biology, Aeronautics, Physics	1
Biology, Practical Science, Physics	1
Biology, Consumer Science, Physics	1
Biology, General Science, Senior Science	1
Biology, General Science, Geography	1
Biology, General Science, Physics	1
Biology, General Science, Everyday Science	1
Biology, Mathematics, Social Studies	1
Biology, English, Senior Science	1
Biology, General Science, Health and Physical Education	1
Biology, English, Health and Physical Education	1
Biology, French, General Science	1
Biology, Chemistry, Physics, Social Studies	2
Biology, Chemistry, General Science, Physics	1
Biology, Geography, Physics, Social Studies	1
Biology, Aeronautics, Physics, Social Studies	1
Biology, Chemistry, Fundamentals of Electricity, Fundamentals of Machines, Physics	1
Biology, Aeronautics, Fundamentals of Electricity, Fundamentals of Machines, Physics	1
Total	217

Combinations Taught by Biology Teachers

Analysis of Table I shows that 65 biology teachers or 29.95 per cent taught only biology. The most frequently occurring biology teaching combinations were biology-general science, biology-chemistry, biology-social studies, biology-mathematics, biology-physics, biology-health and physical education, and biology-English.

Two subjects were taught by 115 teachers or 53.00 per cent of the biology teachers. Three subjects were scheduled for 30 teachers or 13.82 per cent of the biology teachers. Four subjects were taught by five teachers or 2.30 per cent of the biology teachers. Five subjects were scheduled for two teachers or 0.92 per cent of the biology teachers.

Table II. Combinations Taught by Chemistry Teachers

Chemistry	21
Chemistry, Physics	33
Chemistry, Biology	17
Chemistry, Mathematics	9
Chemistry, General Science	8
Chemistry, Senior Science	2
Chemistry, Aeronautics	2
Chemistry, Fundamentals of Machines	1
Chemistry, Related Science	1
Chemistry, Latin	1
Chemistry, Radio	1
Chemistry, General Science, Physics	7
Chemistry, Biology, Physics	6
Chemistry, Aeronautics, Physics	5
Chemistry, Mathematics, Physics	4
Chemistry, Physics, Senior Science	3
Chemistry, Biology, General Science	2
Chemistry, General Science, Mathematics	2
Chemistry, Physics, Radio	2
Chemistry, Physics, Manual Arts	2
Chemistry, Health and Physical Education, Physics	1
Chemistry, Fundamentals of Electricity, Fundamentals of Machines	1
Chemistry, Physics, Related Science	1
Chemistry, Applied Science, Physics	1
Chemistry, Physics, Social Studies	1
Chemistry, Manual Arts, Physics	1
Chemistry, Biology, Geography	1
Chemistry, Aeronautics, General Science	1
Chemistry, Fundamentals of Machines, Physics	1
Chemistry, Biology, Mathematics	1
Chemistry, Fundamentals of Electricity, Health and Physical Education	1
Chemistry, Biology, Physics, Social Studies	2
Chemistry, Fundamentals of Electricity, Fundamentals of Machines, Physics	2

TABLE II (Continued)

Chemistry, Aeronautics, Physics, Senior Science	1
Chemistry, Aeronautics, General Science, Physics	1
Chemistry, Mathematics, Physics, Senior Science	1
Chemistry, Aeronautics, Agriculture, Radio	1
Chemistry, Biology, General Science, Physics	1
Chemistry, Manual Arts, Mathematics, Physics	1
Chemistry, Aeronautics, Physics, Radio	1
Chemistry, Aeronautics, Mathematics, Physics	1
Chemistry, Mathematics, Physics, Pre-Induction Science	1
Chemistry, Biology, Fundamentals of Electricity, Fundamentals of Machines, Physics	1
Chemistry, Fundamentals of Electricity, Fundamentals of Machines, Mathematics, Physics	1
Chemistry, Aeronautics, Fundamentals of Electricity, Mathematics, Physics	1
Total	156

COMBINATIONS TAUGHT BY CHEMISTRY TEACHERS

Examination of Table II reveals that 15 chemistry teachers or 13.46 per cent taught only chemistry. The most frequently occurring chemistry teaching combinations were chemistry-physics, chemistry-biology, chemistry-mathematics, chemistry-general science, chemistry-general science-physics, chemistry-biology-physics, chemistry-aeronautics-physics, and chemistry-mathematics-physics.

Two subjects were taught by 75 teachers or 48.08 per cent of the chemistry teachers. Three subjects were scheduled for 44 teachers or 28.21 per cent of the chemistry teachers. Four subjects were taught by 13 teachers or 8.33 per cent of the chemistry teachers. Five subjects were scheduled for three teachers or 1.92 per cent of the chemistry teachers.

TABLE III. COMBINATIONS TAUGHT BY GENERAL SCIENCE TEACHERS

General Science	72
General Science, Biology	47
General Science, Mathematics	31
General Science, Social Studies	16
General Science, Geography	13
General Science, Health and Physical Education	10
General Science, English	9
General Science, Chemistry	8
General Science, Home Economics	5
General Science, Physics	4
General Science, Commercial	3
General Science, Latin	2
General Science, Visual Education	1
General Science, Senior Science	1

TABLE III (Continued)

General Science, Spanish	1
General Science, Guidance	1
General Science, Radio	1
General Science, Fundamentals of Electricity	1
General Science, Agriculture	1
General Science, Spelling	1
General Science, Psychology	1
General Science, Chemistry, Physics	7
General Science, Biology, Mathematics	3
General Science, Mathematics, Social Studies	3
General Science, Geography, Social Studies	2
General Science, Biology, Chemistry	2
General Science, Health and Physical Education, Mathematics	2
General Science, Latin, English	2
General Science, Chemistry, Mathematics	2
General Science, Geography, Physics	2
General Science, Aeronautics, Physics	2
General Science, Mathematics, Physics	2
General Science, Aeronautics, Chemistry	1
General Science, Physics, Senior Science	1
General Science, Manual Arts, Mathematics	1
General Science, English, Mathematics	1
General Science, Mathematics, Senior Science	1
General Science, Biology, Senior Science	1
General Science, Biology, Geography	1
General Science, Guidance, Social Studies	1
General Science, Agriculture, Manual Arts	1
General Science, English, Related Science	1
General Science, Home Economics, Mathematics	1
General Science, Fundamentals of Electricity, Fundamentals of Machines	1
General Science, Biology, Physics	1
General Science, Aeronautics, Senior Science	1
General Science, Mathematics, Pre-Induction Science	1
General Science, Biology, Latin	1
General Science, Biology, Everyday Science	1
General Science, Biology, Health and Physical Education	1
General Science, Biology, French	1
General Science, Aeronautics, Chemistry, Physics	1
General Science, Biology, Chemistry, Physics	1
General Science, Fundamentals of Electricity, Physics, Senior Science	1
General Science, Health and Physical Education, Physics, Senior Science	1
General Science, Mathematics, Reading, Social Studies	1
Total	282

COMBINATIONS TAUGHT BY GENERAL SCIENCE TEACHERS

Table III points out that 72 general science teachers or 25.53 per cent taught only general science. The most frequently occurring general science teaching combinations were general science-biology, general science-mathematics, general science-

social studies, general science-geography, general science-health and physical education, general science-English, general science-chemistry, general science-chemistry-physics, general science-home economics, and general science-physics.

Two subjects were taught by 157 teachers or 55.67 per cent of the general science teachers. Three subjects were scheduled for 48 teachers or 17.02 per cent of the general science teachers. Four subjects were taught by five teachers or 1.77 per cent of the general science teachers.

TABLE IV. COMBINATIONS TAUGHT BY PHYSICS TEACHERS

Physics	15
Physics, Chemistry	33
Physics, Aeronautics	10
Physics, Mathematics	8
Physics, Biology	5
Physics, General Science	4
Physics, Health Education	1
Physics, Industrial Science	1
Physics, Chemistry, General Science	7
Physics, Biology, Chemistry	6
Physics, Aeronautics, Chemistry	5
Physics, Chemistry, Mathematics	4
Physics, Chemistry, Senior Science	3
Physics, General Science, Mathematics	2
Physics, Chemistry, Manual Arts	2
Physics, Chemistry, Radio	2
Physics, General Science, Geography	2
Physics, Aeronautics, General Science	2
Physics, Biology, Consumer Science	1
Physics, Aeronautics, Senior Science	1
Physics, Chemistry, Health and Physical Education	1
Physics, Chemistry, Related Science	1
Physics, Applied Science, Chemistry	1
Physics, Manual Arts, Mathematics	1
Physics, Biology, General Science	1
Physics, Aeronautics, Biology	1
Physics, Chemistry, Social Studies	1
Physics, Chemistry, Manual Arts	1
Physics, Chemistry, Fundamentals of Machines	1
Physics, General Science, Senior Science	1
Physics, Biology, Practical Science	1
Physics, Fundamentals of Machines, Senior Science	1
Physics, Fundamentals of Electricity, Fundamentals of Machines	1
Physics, Fundamentals of Machines, Industrial Science	1
Physics, Biology, Chemistry, Social Studies	2
Physics, Chemistry, Fundamentals of Electricity, Fundamentals of Machines	2
Physics, Aeronautics, Chemistry, Senior Science	1
Physics, Aeronautics, Chemistry, General Science	1
Physics, Chemistry, Mathematics, Senior Science	1
Physic, Biology, Chemistry, General Science	1

TABLE IV (Continued)

Physics, Chemistry, Manual Arts, Mathematics	1
Physics, Aeronautics, Chemistry, Radio	1
Physics, Aeronautics, Chemistry, Mathematics	1
Physics, Chemistry, Mathematics, Pre-Induction Science	1
Physics, Biology, Geography, Social Studies	1
Physics, Fundamentals of Electricity, General Science, Senior Science	1
Physics, Aeronautics, Manual Arts, Mathematics	1
Physics, General Science, Health and Physical Education, Senior Science	1
Physics, Aeronautics, Biology, Social Studies	1
Physics, Chemistry, Fundamentals of Electricity, Fundamentals of Machines, Biology	1
Physics, Chemistry, Fundamentals of Electricity, Fundamentals of Machines, Mathematics	1
Physics, Aeronautics, Chemistry, Fundamental of Electricity, Mathematics, Physics	1
Physics, Aeronautics, Biology, Fundamentals of Electricity, Fundamentals of Machines	1
Total	149

COMBINATIONS TAUGHT BY PHYSICS TEACHERS

Analysis of Table IV shows that 15 physics teachers or 10.07 per cent taught only physics. The most frequently occurring physics teaching combinations are physics-chemistry, physics-aeronautics, physics-mathematics, physics- chemistry-general science, physics-biology-chemistry, physics-aeronautics-chemistry, physics-chemistry-mathematics, and physics-general science.

Two subjects were taught by 62 teachers or 41.61 per cent of the physics teachers. Three subjects were scheduled for 51 teachers or 34.23 per cent of the physics teachers. Four subjects were taught by 17 teachers or 11.41 per cent of the physics teachers. Five subjects were scheduled for four teachers or 2.68 per cent of the physics teachers.

TABLE V. COMBINATIONS TAUGHT BY TEACHERS OF RELATED SCIENCE, PRACTICAL SCIENCE, INDUSTRIAL SCIENCE, INTERMEDIATE SCIENCE, SENIOR SCIENCE, JUNIOR SCIENCE, FUNCTIONAL SCIENCE, AND EVERYDAY SCIENCE

Related Science	3
Intermediate Science	1
Senior Science	1
Senior Science, Social Studies	9
Senior Science, Mathematics	7
Related Science, Social Studies	5
Senior Science, Biology	3
Senior Science, Chemistry	2

TABLE V (Continued)

Related Science, French	2
Related Science, Mathematics	2
Related Science, Manual Arts	2
Related Science, Chemistry	1
Industrial Science, Physics	1
Senior Science, General Science	1
Functional Science, Biology	1
Practical Science, Biology	1
Related Science, Biology	1
Senior Science, Junior Science	1
Junior Science, Mathematics	1
Senior Science, Fundamentals of Machines	1
Industrial Science, Manual Arts	1
Related Science, Mathematics	1
Practical Science, Mathematics	1
Senior Science, Chemistry, Physics	3
Senior Science, Mathematics, Social Studies	2
Senior Science, Biology, Health and Physical Education	2
Senior Science, Aeronautics, General Science	1
Related Science, English, General Science	1
Senior Science, Biology, General Science	1
Industrial Science, Fundamentals of Machines, Physics	1
Related Science, Chemistry, Physics	1
Applied Science, Chemistry, Physics	1
Senior Science, General Science, Physics	1
Practical Science, Biology, Physics	1
Senior Science, Fundamentals of Machines, Physics	1
Senior Science, Aeronautics, Physics	1
Senior Science, General Science, Mathematics	1
Everyday Science, Biology	1
Senior Science, Biology, English	1
Senior Science, Aeronautics, Mathematics	1
Junior Science, Aeronautics, Health and Physical Education	1
Industrial Science, Health and Physical Education, Mathematics	1
Intermediate Science, Commercial, Conservation	1
Senior Science, Aeronautics, Chemistry, Physics	1
Senior Science, Chemistry, Mathematics, Physics	1
Senior Science, Fundamentals of Electricity, General Science, Physics	1
Senior Science, General Science, Health and Physical Education, Physics	1
Total	77

SUMMARY

Approximately, 80 per cent of the biology and general science teachers were scheduled to teach not more than two subjects. Approximately, 60 per cent of the chemistry teachers and 40 per cent of the physics teachers taught not more than two subjects.

Slightly over one-third of the science teachers taught biology. One-fourth of the science teachers taught chemistry. Slightly over two-fifths of the science teachers were scheduled to teach

general science. Three-fifths of the science teachers were scheduled to teach general science or other sciences closely allied to general science. Slightly less than one-fourth of the science teachers were scheduled to teach physics.

Slightly less than one-third of the teachers included in this study taught one science subject.

U. S. AIRFORCE TRANSPORTS RCA SHORT-WAVE STATION FROM ITALY TO SOUTHERN FRANCE

A complete commercial short-wave radio station, weighing twenty-five tons, has been transported hundreds of miles by air for the first time in history, from Italy to "Somewhere in Southern France," according to word received here today by RCA Communications, Inc.

Moved at the request of the U. S. Army, the equipment was transported within a few hours by the coordinated efforts of the Army Signal Corps, RCA technicians under the supervision of Thomas D. Meola of Skaneateles, N. Y., and the Twelfth Airforce. Service will be limited to Government, press, and EFM (Expeditionary Force Message) traffic. No straight commercial messages may be accepted.

In a radiogram describing the station's movement by air, Merrill Mueller, National Broadcasting Company correspondent attached to Supreme Headquarters, Allied Expeditionary Forces, in France, said: "Fourteen C-47's moved entire twenty-five tons of equipment, which included generators so heavy it took heavy cranes to load and unload them, in a few hours, whereas surface transportation on both sea and land would have taken days and, perhaps, weeks. Thus, another important step has been taken to facilitate communications with Southern France within a few weeks through the day and night-long work of all concerned."

$93,500 IN SCHOLARSHIPS AWARDED SCIENCE TALENT SEARCH WINNERS

Scholarships worth almost $82,500 have been awarded the 300 winners of the second annual Science Talent Search, completed in 1943, to help them through their first year of college, Watson Davis, director of the Science Clubs of America, sponsors of the competition, announced recently. This amount is the total granted by colleges and universities, exclusive of $11,000 in Westinghouse Science Scholarships, awarded as a direct result of the Science Talent Search.

"As originally set up," Mr. Davis said, "the Science Talent Search itself contemplated making scholarship awards only to its 40 finalists. The selection of an additional 260 young people for honorable mention awards was intended to call the attention of colleges and universities to a larger group of unusually gifted youths. To our gratification, educators have come to look upon these honorable mention winners as potential scientists worthy of scholarship assistance.

"Scholarships awarded the 1943 honorable mention winners averaged $208 for the entire group of 229 winners from whom the questionnaire was received," Mr. Davis said, "while the scholarships received by the 39 finalists who reported averged an even $500 per student." These figures are based on first year scholarship only and exclude Science Talent Search scholarships.

THE PROBLEMS OF READING IN MATHEMATICS

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Mathematics presents reading problems that are both similar and dissimilar to those encountered in general reading. There is unanimity among the authorities in the field of reading as regards the function of the teachers of all content areas to develop the reading techniques that are essential for effective and efficient reading in the specific area. These authorities claim that the teachers of each content subject know best the specific purposes for which the reading in that subject is done. They should know the unique burdens of that subject upon the student's reading abilities, and they should understand reading problems of the particular subject. It is logical, then, that the teacher of mathematics should be concerned with the reading problems of his teaching field.

It is the purpose of the writer, who is a teacher of mathematics, to pick out some of the basic problems of general reading and to relate them to the problems of reading in the field of mathematics, pointing out similarities and differences in the reading problems. The problems to be discussed are: the problem of vocabulary, the problem of reading symbolism, the problem of recognizing relationships, the problem of reading explanatory passages, the problem of reading verbal problems, and the problem of reading to follow directions.

RELATIONSHIP BETWEEN READING AND MATHEMATICS

Studies have shown that there is a positive statistical correlation between success in general reading and mathematical achievement. Such correlation is not strange when one considers the close relationship between the techniques involved in reading in the two fields. In the early stages the reading activities of the child are characterized by developing word meanings by using verbal symbols in connection with actual experiences and later by using words to represent these experiences. For example the child, when he begins school, may have had some experience at home with a cat. The teacher, capitalizing on the experiential background of the child with cats, encourages the child to

verbalize his experiences about cats. The picture of a cat is introduced, and the teacher and children talk of their experiences with cats. As the discussion is carried on, the teacher may write on the blackboard words, phrases, and sentences relating to the experiences with cats. The children bring meaning to the written material which becomes the content of reading—in this case, literary.

The capacity to draw generalizations from experiences and the ability to see the implications for experience are two distinct and important processes in mathematics. To illustrate, by various methods the child is taught that the mathematical symbol y represents the cost of one shoe. He then is led to see that $y+2$ may be the cost of a different shoe. It can be shown that the cost of a pair of the first type of shoes will be $y+y$ or $2y$. A pair of the second type of shoes will cost $y+2$ plus $y+2$ or $2y+4$. The term xy, a generalization or extension of the specifics, may be shown to represent the cost of any number of the first type of shoes. Similarly, $x(y+2)$ is a generalization of the cost of x number of the shoes of the second type.

It is apparent that algebra is an extension of the specifics to generalizations. It is also apparent that experience must be had with specifics before the child can bring meaning to the symbols. Reading extends the experiences with symbols and aids in clarification of the meaning of the symbols. Reading of mathematical material involves the understanding of concepts and relationships of quantity. The understanding of these mathematical concepts is not a part of the child's general reading experience. Therefore, it is a part of the responsibility of the mathematics teacher to develop these understandings. Success in mathematics depends a great deal on the ability to read and understand mathematical concepts in situations involving their symbolization.

Thus, Buckingham[1] points out that the relationship between silent reading and ability in first year algebra is positive. He found coefficients of correlation ranging from .25 to .40 between silent reading and ability in first year algebra. Stright[2] found that special instruction in general reading skills was reflected in proficiency in algebra. Lessenger[3] found that special instruction

[1] Guy E. Buckingham, "The Relationship Between Vocabulary and Ability in First Year Algebra," *Mathematics Teacher*, XXX (February, 1937), pp. 76–79.

[2] Isaac L. Stright, "The Relation of Reading Comprehension and Efficient Methods of Study to Skill in Solving Algebraic Problems," *Mathematics Teacher*, XXXI (December, 1938), pp. 368–372.

[3] W. E. Lessenger, "Reading Difficulties in Arithmetical Computation," *Journal of Educational Research*, XXI (April, 1925), p. 288.

in general reading skills raised the arithmetic age as measured by the Stanford Achievement Test in mathematics by five months. It may be concluded that there is a definite relationship of general reading abilities to success in mathematics.

It follows, then, that much of the efforts of teachers of mathematics should be directed toward the teaching of reading in their field.

It will be well to consider the specific problems of reading in mathematics, point out the similarities and dissimilarities, and to suggest techniques by which these problems might be solved.

The Problem of Vocabulary

In general reading the development of vocabulary is a major problem. The individual has to attach meanings to the word, sometimes associating two or more distinct meanings with it. In like manner, the individual in acquiring a vocabulary in algebra has to do the same things. However, these differences are noted: words used in the conventional algebra textbook are very remote from the specific experiences of the child, contextual clues are at a minimum, and association is limited. Words such as "equation," "formula," "coefficient," "polynomial," and "quadratic" often become great obstacles to further understanding. The meaning backgrounds must be developed by the teacher to increase the effectiveness of the reading; that is, to facilitate the understanding, interpretation, and appreciation of what is read. The development of a meaningful vocabulary is a measure of the skill of the teacher. The responsibility for developing meaningful algebraic term rests with her. The teacher must use well-defined procedures for developing the abilities involved in mastery of a broad and accurate meaning vocabulary.

Among the several techniques for developing mastery of vocabulary are: first, the discovery and use of contextual clues and the general use of the dictionary, provided that the student has a rather keen sensitivity for meanings; second, the use of configuration or the form of the word; third, the use of phonetic analysis; fourth, the use of prefixes and suffixes; and fifth, the use of words within words.

In the statement: "The factors of a product may be grouped in any manner," the child may have difficulty in learning the meaning of the word "factor." He is given the statement: "The ______ of a product may be grouped in any manner." By asking

him what words will make the sentence meaningful to him, he may, after exploring one or several possibilities, get the true meaning of the word. The source of his difficulty may be that he has not disassociated his other concepts of the word here "specialized." For example, the student, in his social studies book, may see the word "factor" in the sentence: "Labor is a factor of production," or he may have a generalized idea as expressed in the sentence, "This is an important factor." The teacher's job here, as implied previously is: first, lessening the variations of the associations; second, having the pupils get the specialized meaning in vocabulary drills when the word is exposed in isolation.

By using configurations of words the child can improve his recognition techniques. For example, such words as "binomial," "trinomial," and "polynomial" possess the same root. The teacher can aid the pupil by having him build families of words and noting their similarities and differences. Illustrations of the other techniques could be found with little or no difficulty.

Symbolism

In general reading symbolism presents serious reading problems. Among other things, the reasons for these problems are related to the number of new or strange words in a sentence or paragraph, the complex structure of sentences, and the number of ideas per paragraph. In the study of algebra, not only is there a large number of words which are completely new to the pupils, but there are many algebraic symbols with little or no meaning when taken out of context. Another striking difference between the symbolism of general reading and algebraic symbolism is that the content per unit—the line or paragraph—is often three or four times as great as that of general language. For example, $d=rt$, $c=\pi d$, and $i=prt$ may represent sentences and even paragraphs. If we extend our thinking to statistical symbols, such as "sigma," we find that much may be told by the one symbol.

The reading of algebraic symbolism presents a difficult problem. Three types of algebraic symbols must be mastered: ***number symbols***, ***operational symbols***, and ***directional symbols***. Number symbols, for example, a, c, x, and y must acquire meaning through definition and use. Similarly, operational symbols for "plus," "minus," and "times" have no meaning except through use. The two directional symbols are difficult to master, particularly the negative sign.

It is extremely important that the teacher of algebra have the pupils understand that letters such as x, y, and z are number symbols. When the pupil lets t represent time, he should mean "the number of units of time required to perform a certain act by a particular means."

To understand the operational symbols for "addition," "subtraction," "multiplication," "division," "square root," and "cube root" the student must understand the operation to be performed and the relationship implied. For example, the question, "Five times which number when added to two will give a total two times the same number added to eighteen?" can hardly be answered unless the pupil has understood the operations described and the relationship of the two sums.

Directional symbols are used very early in the study of algebra. The student must have an enlarged meaning of the minus sign not only to convey the idea of subtraction but to understand it as an indication of movement in a direction on a scale opposite to a movement on the same scale in a direction indicated by the plus sign. When the concept of direction is fully understood the student will have less difficulty with such statements as $-30+6=-24$.

Problem of Recognizing Relationships

The problem of recognizing relationships expressed by the formula, equation, and graph is serious. In general reading one uses verbal material almost exclusively. Relationship is generally shown by comparison and contrast by use of the mechanics of grammar. In mathematical reading one must be able to relate graphs, formulas and equations to verbal material, or he must be able to supply adequate verbalism to interpret these methods of showing relationship.

The formula is a shorthand summary of a rule which expresses relations between numbers or quantities. The ability to use a formula correctly in even the simplest way involves several subabilities: first, the ability to interpret the symbols; secon l, the ability to substitute numerical values for literal numbers; third, the ability to interpret the results. The structure of the formula presents reading difficulty. Tinker[4] showed in his study of photographic records of eye movements in reading formulas in context

[4] Miles A. Tinker, "Eye Movements in Reading Formulae," *General Psychology Monograph* (February, 1928), pp. 69–182.

that greater demands are made on the eye than in reading either scientific prose or algebraic narration. He believes that children should be taught by logical processes to apprehend the relationship of the various elements of the formula. Teaching the pupils to note details and to follow directions is essential if there is to be mastery of the meaning and manipulations involved in the formula.

Durell[5] suggests that the foundation may be built in several steps:

1. The construction of rules governing practical problems by familiar methods.
2. Verification of given relations and evaluations of simple expressions by substitution.
3. Practical applications of formulas.
4. General enunciation derived by inspection and analysis of grouped data.

The implications of the role of reading in the above are far-reaching.

In the treatment of the formula one automatically deals with the equation. The formula usually expresses relationships that are found in situations which are actual applications. The equation is a more limited statement made by the use of symbolism. Much practice in reading symbolic language and translating symbolic language into verbal language should be provided. For example, training in translating the two languages may be given in such exercises as the following.

1. $n+2$, namely, the sum of n and 2.
2. $n-4$, the difference between n and 4.
3. $7n$, the product of 7 and n.
4. $5(n+6)$, five times the sum of n and 6.
5. Change the symbolic expression $2a+6=12$ into an English statement.

Another source of difficulty in the language of algebra is the reading of graphs. The ability to understand the meaning of the graph involves several abilities; first, to understand the title; second, to understand the meaning of the reference axes; third, to understand the scale and symbols of graphs; fourth, to recognize the change in one variable corresponding to a change in the other variable; fifth, to get the facts portrayed in the graph; sixth, to interpret the facts derived from the graph; and seventh,

[5] Clement V. Durell, *The Teaching of Elementary Algebra*, pp. 29–30. London: G. Bell & Sons, Ltd., 1931.

to restrain the interpretation within the reasonable limits provided by the graphical data. The teacher of algebra must train the pupils to read captions, keys, and legends. She must help the pupils to visualize from symbols to reality. She must elicit from students the facts given from the graph. And finally, she must ask thought questions that require an interpretation of facts derived from graphs.

Problem of Reading to Follow Directions

In general reading the reader has wide latitude in reading to follow directions. The reader may often overlook some details without altering his general directions. In mathematics the directions are precise. For example, "Let the total cost equal c," "let x equal 3," "divide by 3," and "add 3 to each member of the equation" are precise directions to be followed, and any deviations will change the results obtained. The teacher must develop on the part of the pupils: first, the ability to read word sequences carefully step-by-step; second, ability to understand each step in the sequence; and third, ability to maintain the original order of the sequence.

Problem of Reading Verbal Problems

Teachers of algebra are rather vocal in regard to the difficulties encountered in the reading of verbal problems in the study of algebra. Verbal problems demand on the part of the student consumption of more information per unit than general reading. Verbal problems differ in degree and kind, ranging from types in which the verbal language may be translated directly into algebraic equations and readily solved, to those in which the quantities are so intricately related as to tax the mental ingenuity of the pupil. Among the things necessary to solve verbal problems are: (1) skill in techniques of silent reading; (2) knowledge of technical language of algebra; (3) understanding of the social and mechanical situations involved in the problem; and (4) skill in performing the algebraic operations.

The difficulties encountered in the reading of verbal problens are recognized by research workers and philosophers. Stevenson[6] cites, among others, the inability to read on the part of the student and the lack of general and technical vocabulary as

[6] P. R. Stevenson, "Difficulties in Problem Solving," *Journal of Educational Research*, II (February 1925), pp. 91–103.

serious problems. Osburn[7] also lists these two inabilities as sources of difficulty.

To read verbal problems effectively the student must be able to select key words; he must be able to distinguish between relevant and irrelevant facts; he must be able to recognize familiar terms; he must be able to interpret the problem in light of the punctuation used and in light of the relations existing among parts of the problem.

In summarizing, the writer has pointed out several major problems of reading in algebra and has indicated their specific nature in the case of vocabulary, the symbolism, the methods of expressing and recognizing algebraic relationships, and verbal problems. These problems are not the primary concern of teachers of general reading. They are the specific responsibilities of teachers of mathematics. They must develop the concepts and relationships to reading and understanding mathematical material. Therefore, the reading skills and techniques required for mathematics must be taught by teachers of mathematics.

[7] W. J. Osburn, *Diagnostic and Remedial Treatment of Errors in Arithmetical Reasoning*. Madison, Wisconsin: State Department of Public Instruction, December, 1922.

PSYCHOLOGIST WARNS AGAINST "SOFT" OR "HARD" PEACE FOR GERMANY

To make a lasting peace with Germany, conditions must be arranged for the Germans to reconstruct their culture toward a peaceful, democratic one, Lyman Bryson, director of education for Columbia Broadcasting System and professor of education at Teachers College, Columbia University, declared at the meeting of the National Committee for Mental Hygiene.

Prof. Bryson advises a "stern" peace, rather than either a "soft" or "hard" one.

"What will get for our children the kind of future we want" is the real issue, not the question of what kind of peace the Germans deserve, he pointed out.

"The psychologists warn us of two dangers that must be avoided," he stated. "In the first place, the American people must not indulge in a fury of hatred and revenge and in that mood inflict severe punishments which they are certain in the future to regret because in their mood of regret they will be easy victims for German propaganda.

"The second danger is to suppose that the Germans will respond to the same kind of appeals, and are actuated by the same kind of motives, as we are ourselves. The last 75 years of German culture have developed, in normal German men and women, strains and anxieties that find a natural expression in aggressive violence. What the psychologist wants is the kind of peace that will enable the Germans themselves, with the help of stern controls imposed from the outside, to reconstruct their culture so that it will produce men and women of peaceful and democratic tendencies."

ADAPTING INSTRUCTION IN SCIENCE AND MATHEMATICS TO POST-WAR CONDITIONS AND NEEDS*

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Any curriculum or course of study should be developed and continuously revised in the light of three major considerations:

(1) the nature of the group of learners for whom it is intended—their ability to learn, including their general capacity for learning, their background of information, concepts, and vocabulary for the particular field, and their skills in that field, their interests and their probable present and future needs.

(2) the conditions and trends of life which play a part in determining what our problems and educational needs are and are likely to be.

(3) current developments in the subject fields—new materials and changes in the relative importance of various materials.

Courses of study should always be in a state of growth and development so as to be kept in as close adjustment to changes in these three areas as possible. There will always be a lag, greater or less. Bertrand Russell, famous British philosopher and mathematician, once said, "The schools are driving the tacks where the carpet was last season."

We have been and are now living in a period in which unusually significant changes have been and are taking place in all three of these areas. The post-war world will be indeed, for those interested in the teaching of science and mathematics, one quite different in important respects from the pre-war world. In planning for teaching in the post-war period we are confronted with new conditions, with new developments, with changes in relative importance of many items of our subject matter, and with an increasingly challenging lag and increasing maladjustment of our courses of study. It is well that we seem to be in a frame of mind of taking stock and surveying with a view to revising our offerings.

THE POST-WAR STUDENT BODY

Beginning in 1945, we shall see within a few years the number

* An address before the Annual Convention of the Central Association of Science and Mathematics Teachers November 24, 1944 at the Stevens Hotel, Chicago.

of high school students shoot up past seven million and probably by 1950, approach eight million. Jobs will soon not be plentiful for people under eighteen or twenty, and millions of parents with more money than ever before will not only be able to finance secondary education for their offspring, but will be desirous of having them take advantage of the opportunity to better themselves and to contribute to the social prestige of the family.

We can confidently count on huge increases in college and junior college enrollments, not only of returned service men, but of young people of this new generation of well-to-do parents. At the University of Colorado this year the enrollment of freshman girls is a third greater than in the best pre-war year.

If and when a recession or a depression comes, as is more than likely, it will no doubt result in smaller enrollments in universities and four year colleges, but in high schools and junior colleges it is more than likely to contribute to even greater enrollments of young people, who, unable to obtain employment, will continue their schooling if it can be done without leaving home.

The presence of such large numbers of young people in school will constitute the resumption of a significant shift, under way for several decades previous to the war, in the composition and center of gravity of the young people in our classes. To some extent at least, they will be possessed of a lower average ability to comprehend and to retain. These newer recruits to secondary and higher education come disproportionately from the ranks of those of lower intelligence.

Of even greater importance, these new comers will without doubt, as was the case in the half century prior to 1940, be in the main characterized by a relative lack of interest in intellectual and bookish materials and activities and in forward looking preparation for later life. It is only to be expected that in periods of less universal attendance in schools, those of less academic interest, perhaps even more than those of less academic ability, tend to be among those leaving school early.

Thirdly, of very great importance to curriculum makers—and all teachers are more or less curriculum makers—their future needs will be significantly different from those of greater intelligence, intellectual interest, and character, inasmuch as they will for the great part gravitate towards the so-called lower vocational and economical levels, living under characteristic conditions of life and meeting problems characteristic of their

fellows. They will be compelled to do more of their own repair work and child care, and to spend their earnings more thriftily.

In the fourth place the "other half" will come in disproportionate numbers from homes of less cultural atmosphere, of less well educated parents and homes in which there is less opportunity and stomach for learning. Consequently they come to our classes with an inferior background, lower morale, and inferior opportunities for home study.

Now all of these characteristics of the new high school and college student are meaningful for curriculum construction and revision. It is not wise, only impractical, to ignore these things, to fight rather than to adjust to these new conditions.

While the limitations of this paper do not permit a lengthy detailed analysis of all these matters, a number of the important implications of the nature of the post-war student body may be briefly enumerated. For them instruction must be less verbal, taught in connection with applications to situations arising in life, involving a smaller vocabulary load and should insure care in seeing that meanings of technical words are clearly comprehended. For them more attention must be given to surveying the background they bring to our classes in order that we may know upon how little we have to build.

The "other half" must be given instruction which will serve the future needs of men and women who will not go to college, may not complete high school—instruction which will serve the needs of youths who will go into the widest variety of less well paid occupations—factory hands, clerks, farmers, packing house employees, miners, truck drivers, cooks, bakers and waitresses, and scores of similar occupations. The greater majority of girls in the "other half" will be the wives of workers in these classifications. The curriculum maker-teacher must visualize the working and living conditions of these youngsters when they grow up and the educational needs indicated as a necessary first step in planning for their instructional needs. This fact seems all the more important in the light of the propensity of teachers with their limited out-of-school experience to think only of preparation for college and the professions, and for culture of a level assimilable only by those of greater intelligence and keener intellectual interests.

Increased Importance of Problem of Motivation

The fact that those of the lower half are characteristically less

interested and "interestable" in verbal and academic materials and activities is further complicated by recent and current developments in the area of free and commercialized entertainment. Operating to distract young people and many of their elders, and to divert their attention to stimuli and experience more appealing than typical schoolroom activities, the opportunity for entertainment of great appeal has grown by leaps and bounds and is all the more formidable coming as it does along with the diminished and diminishing willingness to attend to the more difficult and less attractive, though more valuable, things in life. The movies wielded an influence distracting and dissatisfying enough in themselves, but today the radio brings at all times of day and night to the ears and imagination of practically all youngsters except in the poorest homes—thrills of adventure, excitement, prowess and humor which make exceedingly unsatisfying, if not indeed unpalatable, such things as exercises and problems in arithmetic and geometry and perhaps to a lesser extent the assigned lesson in biology and physics.

The returning service man will constitute a similar problem. Both his time and patience are likely to be short. He has experienced instruction of a type highly motivated, condensed, practical, concrete, involving realistic activity, aimed at objectives relatively obvious and important. He is almost certain to fret at covering grounds in books on little disconnected chunks principally for the purposes of recitation and examination.

What Can Be Learned from Education in the Armed Services

Maybe paradoxically, we can hope to learn not a great deal from instruction in the armed services and their schools which we can apply in high school and college. The situation is greatly and significantly different. The objectives are fundamentally different. Instructors in the armed services were concerned with a few specific things—not a broad education. In the most part theories and understandings were limited to those essential to doing a small number of certain and specific things. Learning was highly motivated—both by the natural situation and by rewards and punishments that are not available to us. Expense was no consideration. Classes were as small as need be and all the teaching paraphernalia asked for was obtained. Activities not books were to be learned.

Perhaps we can learn a few things from experience in the serv-

ice schools and camps. Among them may be the following:

1. To use more visual aids of all kinds.
2. To concentrate upon the more useful and valuable objectives and materials and upon appropriate mastery or growth, and to eliminate great masses of relatively less useful materials and details—long circuitous approaches.
3. To employ more doing, especially on the part of the less intelligent learners.
4. To take seriously the matter of instruction and to relegate secondary activities such as extra-curricular activities to a marginal place, or to re-organize them fundamentally so that they will contribute definitely and appropriately to the objectives of the school.
5. To focus upon learning progress, not upon teaching activities, traditional ceremonies or the prestige of the teacher as such.
6. To learn to select, organize and reorganize learning materials so as to contribute most effectively to the product sought and to clearly conceived objectives, rather than to focus upon causing pupils better to learn off static and preconceived bodies of subject matter—trusting that thereby the cause of education may somehow be served and condoning that easy approach by high-sounding, vague arguments and generalities which are not convincing as clean cut logic or reasoning.

Pertinent Post-War Conditions and Trends

Now I must turn to what is perhaps the most important consideration of this paper—namely what will be the characteristics and activities of the post-war world which will be new or different and significant to instruction in science and mathematics. The following is an attempt to enumerate a number of them and to indicate briefly their respective significance:

1. First of all, though by no means most important, is the fact that in the post-war period we will rapidly become a world of air-transportation. While for at least a decade or so, we will have little need for more men in this country trained for flight and related ground work in addition to the hundreds of thousands we have trained in recent years, we will need to train a few young men and need to give training along lines of new developments yet to come. Rather, we will need to train the future general public to live in a world of air trans-

portation and to understand its significance for international relations. Not new courses will be needed to do this but many little adaptations here and there in our courses—particularly in problem material. Additional instruction about geography, meteorology and about instruments for measurement of a variety of things will be necessary as will of course calculations of distance, position, etc.

2. We will soon see new and more machines, in the home, on the farm, in the factory and in the business house. Few new principles will be involved but we will need to become familiar with many adaptations and applications. Every housewife and her "bitter" half will need to be to some extent an operator and repairman of a variety of machines and instruments—to know about their selection, installation, care and repair, and calculations involved.

3. The housing industry will boom for a decade or so, and a great variety of new developments which have been accumulating on blue prints will be put into practice involving knowledge relative to costs, financing, construction, decoration, new materials, storage and refrigeration and the like.

4. Women and Negroes will continue in industry and their education must be appropriate. The war has opened wide the door and they have made good. The clock will not turn back in this respect.

5. The problem of keeping the peace will be much in the foreground and important educational contributions by mathematics and science are vital. Future citizens for example must be conversant with the essentially equal biological, psychological, and cultural potentialities of all the various national and ethnic groups. Mutual respect and understanding are not only essential to plans of world organization and cooperation and peace, but if sufficiently developed, may actually make any especial organization for peace unnecessary. The war has placed an added burden upon us in this respect. In such times provincialism, K. K. Klanism, and delusions of superiority are generated, to say nothing of the propaganda of exaggeration and deception thought necessary to win the war relative to the characteristic cruelty and bestiality of our enemies—particularly in the indoctrination activities in the armed services.

6. Particularly of significance to mathematics teachers is the development of appropriate mathematical concepts in-

volving the general voter to understand the magnitude and implications of a $300 billion dollar war debt—almost $10,000 a family—certain to cost us in taxes if the government remains solvent, from $300 to $400 annually per family. Promise of one of the candidates for the presidency to extend social security and to reduce taxes at the same time were not convincing in terms of the pertinent arithmetic.

7. The impending threat of unemployment and depression also challenges the instructor in mathematics to tie up his subject with problems in that area—including purchasing power, public works, and the like.

8. We must give more attention to teaching about problems of conservation. We have been facing and will continue to face shortages in lumber and paper, coal and oil, and certain metals. The science of synthetics and other substitutes will be very useful in the post-war world.

9. As has been pointed out by many leaders in the teaching of science in recent years, science instruction is becoming as it should increasingly concerned with the social implications of new inventions, new medical knowledge and new scientific knowledge in general. Modern science teachers, for example, are more and more concerning themselves with what happens to patents to prevent them from being utilized so as to pass on to the masses the full potential benefits of the scientific genius, rather than to be bought up and shelved to protect existing vested interests or to be used for production on a basis of large profits per item on restricted production instead of small profits per item on large scale production. They are concerning themselves more with the relationship between science and invention on the one hand, and monopolies, cartels and tariffs on the other.

10. The development of subject matter in science and the fields of application of mathematics and science goes on apace. With the passing years American life is influenced by new products, new processes, new materials, whole new industries and resulting new social, civic and business practices and problems. Examples of this sort of thing are flying and the aircraft industries, synthetic rubber, fabricated housing, sulfa and other types of new drugs, the uses of molybdenum, and new knowledge about the mind, personality and mental hygiene. To these developments, instruction must be continuously adapted.

11. In recent years the development of commercial and political propaganda has skyrocketed in amount and effectiveness. With mass production and national and international markets, without excessive cost per item sold, huge sums of money have become available for bringing to play upon the potential purchaser pressure by the highest paid artists, musicians, entertainers, and writers. Likewise newspapers even throughout their news columns, periodicals, columnists and radio commentators particularly have become agencies of skillful and systematic propaganda.

The great increase in the pressures brought to bear upon all in American life today call for (a) a much better and broader basic knowledge in science and other subjects, (b) much more training in reading with scientific skepticism and efficient logical criticism and evaluation, and (c) objective skill and habits of reasoning and (d) contact with and practice upon in the school materials of propaganda in print and over the radio as is to be found in typical American life.

12. Along with the increased need for education and along new lines there has developed an intolerable overcrowding of the curriculum. As in one of the Aesop's fables—"all tracks lead in and none lead out." The resulting superficiality and ineffectiveness have increased to the point where several major operations must be performed. It is no longer a matter of what has or has not considerable value. The question now is, what is of highest value. In the interest of better education, students must study less and learn more.

The overcrowding of the curriculum in mathematics in grades 6, 7, and 8, resulting in part from the very wise postponement of difficult topics, which experience has taught us ruthlessly cannot be mastered in the lower grades, has reached the point where something serious must be done about it. Either the general mathematics of these years should be expanded into the 9th grade and algebra postponed a year, for which there is a preponderance of arguments, or drastic surgical operations of amputation. The same situation applies to our present day courses in physics and chemistry. Too much is attempted and too little learned.

We have obviously reached the point where no item of subject matter in high school or junior college science or mathematics can be retained unless it can justify itself clearly upon grounds other than its contribution to general discipline or

transfer of training, or because of its historical or traditional interest or importance. Competing items or units of subject matter with greater functional values also have disciplinary potentialities.

13. In the post-war period the trend toward increased attention to health will be accelerated—both physical and mental. More than twelve million men and women will have enjoyed health and dental service without cost—including millions who would otherwise have had only emergency service. Good physical condition will have been established in their minds as something to be maintained. Millions of service men and women will have been accustomed to a balanced diet who never before had known it. In addition millions of older civilians will have been able to pay for medical and dental service for the first time in their lives.

There will be a resulting increased consciousness of health—of health problems and of health information. Concomitantly great strides have been made in medical science and treatment.

As the result of the huge number of rejections and separation from service because of physical and mental condition, the attention of the general public, as during and after World War I, has been turned to the need for greater attention to health and physical education in the schools.

All these developments set the stage for increased attention to instruction in science topics related directly or indirectly to matters of individual and public health and sanitation.

14. Ideas and ideals of social security accelerate tremendously as the result of the depression and new deal measures have developed materially during these war years. Here as in England, plans for greater social security for civilians as well as for returned service men are now being devised to be soon put into operation. Unemployment prevention and insurance, public nursery schools, medical, nursing and hospital service, especially during maternity periods, child feeding, old age pensions and many similar ideas and plans for state and national governments to protect its people from fear and physical disabilities, will be much discussed and some actually put into operation. Materials and problems related to projects of these types, their costs and support will naturally be employed to greater extent than formerly.

Certain Important Trends and Shifts in Educational Philosophy

1. *Greater Attention to Discipline in Education*

During the war period there has been a very noticeable reactionary demand for a return to greater emphasis upon discipline. In war time our thinking naturally becomes colored with concepts of regimentation and obedience. "Theirs not to question why, theirs but to do and die." In the first year of the war, young men in training camps were put through the mill, given the works, and many were found unable to take it. Hospitals and sick bays quickly overflowed with victims of all sorts of physical and mental afflictions brought on principally by excessive fatigue and worry. Later the training processes were somewhat adapted to the nature of the human material, without serious loss of time. (As an aside, one may be excused for commenting at the much greater softness of the older civilians who bellyached loudly and piteously because of the comparatively infinitesmally minor hardship of food and gasoline rationing and report filling.)

Nevertheless, the soft side of progressive education lost ground, though one may note that the soft side of training in the home actually grew softer as parents took advantage of the situation to saddle upon the schools more responsibility for the hardening of human steel through discipline and so absolve themselves more completely from responsibility.

As time went on, our thinking about discipline has matured. Our boys in uniform turned out to be not only sufficiently susceptible to discipline from without, but superior with respect to discipline from within, to resourcefulness and ingenuity, most desirable in these days of blitzkrieg, unconventional warfare in which decisions not only must be frequently made almost instantaneously in the light of developments which are not predictable but also often by small detachments and frequently by individual warriors. We began to realize more and more, that discipline of the highest sort was not merely responsiveness to command, but also self discipline, discipline from within.

In addition, we have come to realize that discipline for peace and discipline for war are not the same at all. The discipline of youngsters in school today must be for peace. Few of them will ever wear a uniform. They are either too young or too old—too

young for this war and let us hope too old for the next one. We are no longer satisfied with glittering generalities about discipline. We want to know what kind of discipline—discipline in what. There are thousands of disciplines—thousands of habits, ideals, attitudes, skills, and procedures which constitute disciplines and disciplinary products. We must identify those most needed in the post-war period and form our instruction in science and mathematics upon their attainment. Clear thinking about the disciplinary aims of education has long been overdue. Loose talk about discipline has been traditionally the haven of refuge of certain types of teachers where with lip service they could absolve themselves of their sins of sloth, vindictiveness, and thirst for personal power, and of responsibility for good cause of study selection, effective adaptation to the nature of learners, and for good teaching generally.

2. *Trend towards Redistribution of Emphasis upon Types of Educational Objectives*

In the post-war period certain trends toward redistribution of emphases upon various objectives of education are almost certain to continue. Among those likely to continue may be mentioned the following:

a. Less emphases upon detailed information. We are more and more impressed with the illusory and ephemeral nature of items of information and experimental investigation has verified our casual observations. Detailed information will be more and more regarded as grist for a mill to turn out such things as general concepts and principles, attitudes, skills, ideals and interests—all more permanent and more widely applicable.
b. A continued increase in emphasis upon teaching relationship—concomitance or correlation, cause and effect, applications and all sorts of inter-relations.
c. A greater emphasis upon teaching for understanding—the uses, nature, meaning and fields of application of the important things taught. (The National Society for the Study of Education has a committee at work preparing a year book on The Measurement of Understanding.)
d. Greater emphasis upon certain ideas and attitudes essential to international understanding and peace and to the continuation of our march towards the achievement of democracy in this country and elsewhere, e.g.,

1. Attitude of respect toward others of different nationality, color and language
2. Attitude towards ideas—openmindedness, objectivity, etc.
3. Attitude towards ethical standards—justice, fairness, honesty, etc.
4. Attitudes towards procedures of clear thinking
5. Ideals of peace and mutual international helpfulness
6. Ideals of good living standards and security for all

e. Greater recognition in practice of the precious nature of interests and potentiality for interests in the various fields of learning, thought and activity. The devastating extent destruction of the desire to learn more about science and scientific things by teachers in their awkward pressure brought upon students to get lessons and to prepare for examinations is becoming more and more obvious and more and more shocking. A trend, only a minor one until recently, but promising soon to become a major one, is that towards placing upon a pedestal among educational objectives that of building, expanding and directing interest of young people in all phases of science and scientific phenomenum rather than destroying it and building antagonism toward the study of science. Clear thinkers are realizing in rapidly increasing numbers that what we learn in school is not great, and that it tends to disappear and to grow out of date, and that a principal product of schooling is the ability and the desire to continue to learn about science years and decades after formal schooling has been discontinued.

f. Closely allied, is the greater recognition of the importance of mental hygiene as applied to instructional methods and materials. Whatever may be said, truthfully or as the result of wistful thinking about the use of fear, threats, and intimidations as goads to get children to study, the quality of the result has not been high enough to offset the negative or harmful by-products in the form of unwholesome attitudes toward self, towards schools, and towards teachers and classmates.

3. *Trends as to General Plan of Curriculum Organization*

After years of discussion and experimentation with various plans for organizing curricula in areas broader and larger than

the single subject the more permanent trends seem now predictable.

a. Further attempts at a unified curriculum including all or nearly all subjects will not be numerous and the idea will never become widespread. Previous attempts have not been regarded as very successful.

b. The core curriculum, as made up combining several subject fields is also not likely to become more widespread except as in instances in which English and the social studies are combined.

c. The tendency to correlate each field with others seems to be sound and will no doubt enjoy a slow healthy growth.

d. The tendency to combine different areas within a broad field is here to stay, e.g., general science and general mathematics, instead of separate subjects in the junior high school. Experimentation in senior high school in both of these broad fields is in the cards, already under way in many schools, e.g., general physical science often including some geology and meterology, and senior mathematics, including some each of algebra, geometry, trigonometry, and arithmetic.[1]

It is even quite possible that we shall see more attention to biological science in the senior high school in the forms of a general science including general biology, bacteriology, human physiology, health, and related chemistry.

I think we can safely say that attempts to combine mathematics and science are likely to be less numerous than in the past. The trend is definitely not to slight the application of mathematics to business, consumer problems, civic matters, farm and shop in favor of the mathematics of physics, chemistry and engineering.

4. *New Ideas about General Education, College Preparation and Vocational Education.*

The trend of recent years towards general education is not likely to slacken. Attempts to provide curricula and to adapt courses in mathematics and other sciences to the special needs of special groups have not proven as practical as desired and anticipated. Curricula and courses built around the central theme

[1] See article by Blair in bibliography at end of this outline for brief descriptions of plans in 13 schools for teaching arithmetic in the senior high school courses in mathematics. See article by Hollinger and others describing general physical science course in Pittsburgh high schools.

and objective of general education have not only proven popular and practical, but there is much reason to believe that they serve very well the purposes of vocational and college preparatory education. By general education is meant instruction centered on the more common needs of the great majority of people—such areas as health, home problems, civic and character development, recreation, and general vocational intelligence as opposed to courses developed especially for small groups differentiated as to vocation or college going, e. g., science for auto mechanics, commercial arithmetic, the college preparatory curriculum, and the printing curriculum. As a consequence there seems well established a slow trend towards fewer specialized electives and greater adaptation within classes to variation in student interest and needs.

General education science and mathematics courses are including more and more materials of wide application to various types of vocations. This is as it should be. The place of specific vocational training is not secure. With changes in industry and commerce, a larger and larger majority of jobs call for little or no specific training that can not be gotten on the job. There are too many thousands of different occupations today for training to be devised for any considerable proportion of them. Greater and greater reliance will be placed on education for vocation in the general subjects, English, science, mathematics and the social studies.

With reference to college preparation, except for engineering and other technical schools and colleges, larger and larger becomes the question mark confronting the practice of attempting preparation by means of requiring certain subjects. Repeated investigations show that college grades are no more associated with the amount of work in so-called preparatory subjects than with the number of units in social studies and science, if intelligence is held constant. What is more, more recent informal investigations seem to confirm the growing body of testimony by college professors in all fields except physics that for the purposes of preparation for college, mastery of arithmetic and elementary algebra are more important than a half mastery of a larger amount of mathematics.

It is also becoming increasingly evident that it matters not so much what subjects are studied for preparation for college but how they are studied—the important things being a large and precise vocabulary, the ability to read understandingly to

organize ideas, and to see relationships, skill in problem procedures in all fields, and very important, an interest in intellectual matters and fields.

Trends in enrollments in recent decades have also served to lessen the importance of attempting to prepare for college. Such a small proportion of high school will ever go to college much less remain to graduate. Of 100 pupils in the seventh grade in North Central states, as for the U. S. as a whole, less than half will graduate from high school, slightly more than 1 in 10 ever enter college and only about 1 in 20 remain to graduate. Of a class of 35 to 40 seventh graders, only 4 on the average will enter college and only 2 become college graduates. Of a class of 30 to 35 ninth graders only about 6 will enter college and 3 remain to graduate. Of college seniors the expectancies are respectively not greater than 1 in 4 and 1 in 8.

What a Teacher!

All these trends call for a higher grade of teacher—a teacher more broadly informed and of broader interests in other fields and in the areas of application of his subjects. The day of the schoolmarm is just about over. One can no longer wisecrack that mathematics is a lazy man's subject. The situation is like that bemoaned by the fourth grader who complained bitterly that the teacher wasn't fair—"she changed the spelling words on him every day." The world does move. The teacher moves with it or becomes less and less effective, less and less worthy of a place in the driver's seat in the classroom. We teach not for the world of yesterday, nor the world of today but as best we can for the world of tomorrow.

The implications for continued self training and growth in service are somewhat staggering. As a matter of fact, when we left college our education was not only very fragmentary, but for the most part already partly out of date.

There is however a bright side. As never before, small readable reasonably reliable books appear in abundance bringing to us the more significant facts, trends and problems of the present and of the future, to say nothing of short non-technical pamphlets and bulletins in profusion on every subject and of readable articles in an ever growing number of semi-popular periodicals such as the *U. S. News*, *Science News Letter*, *Magazine Digest*, *Fortune*, *Time* and *Common Sense*.

If we want to get out of or keep out of the schoolmarm class,

there is no alternative. Time must be found to read even if we grade fewer papers and pass less time in interesting conversation. If we are to educate for the world in which our pupils will live our faces must be to the future and we must become acquainted with it as well as is permitted us.

Things are moving along so rapidly that we must find out what other schools and other teachers are doing and we must study and evaluate their courses carefully. We cannot afford to rely entirely upon our own resourcefulness. It is neither safe nor economical. I should like to close with a caution. Be slow to adopt what you do not understand clearly. The path of American education is strewn with the calamities of "experiments," the hasty attempts to put into practice ideas and procedures, of which teachers had only a very superficial understanding though the ideas for the most part were essentially sound. From this, God save us. It is least worthy of the exponents of science and mathematics.

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PROFESSOR E. H. TAYLOR RETIRES

Dr. E. H. Taylor, Head of the Department of Mathematics at the Eastern Illinois State Teachers College, has retired. Dr. Taylor has taught in this college since its opening in 1899. His many students and friends will be glad to know that he is in the best of health and plans to spend part of his time in revising his textbooks.

REMAGNETIZATION OF U-MAGNETS

Joseph A. Mack
McBride High School, St. Louis, Mo.

The two types of experimental motors and generators usually found in high school laboratories are the St. Louis Motor and the Genemotor. They differ essentially from each other in the type of permanent magnet employed, the St. Louis Motor using bar magnets while the Genemotor uses a U-magnet.

Through the vicissitudes of use and abuse these magnets need frequent rejuvenation. This remagnetization for a bar magnet is generally possible with existing coils and currents available in any laboratory. But the U-magnet, for a complete remagnetization, presents a more difficult problem. Makeshift magnetization is possible, but that did not satisfy us. "Do it right!" was our slogan.

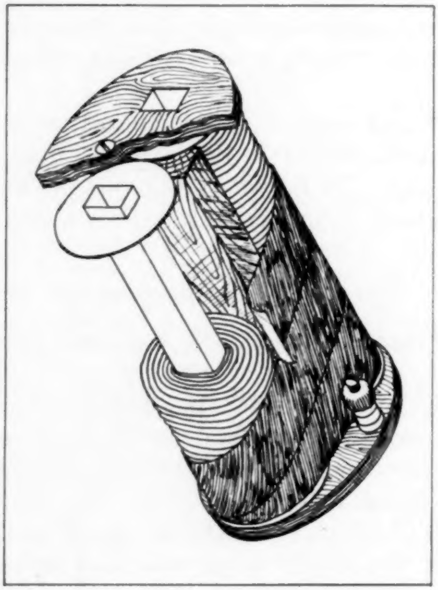
We wrote to the supply houses on what magnetizing force would be required. Their scientist learnedly discussed oersteds, reluctance, *et alia*, but he would not commit himself to such everyday language as ampere-turns. So we went ahead on a pragmatic basis.

Design and Construction

Designs for magnetizing a single U-magnet seemed wasteful. Thus, the first consideration was to lay two U-magnets end to end and consider the coil binocular. The rectangular cross-section of the magnets was another determining factor; so also was the length of the straight sides of the magnets when laid end to end. This length was found to be 19 cm. The clearance between the two prongs (5 cm.) was another factor. With these measurements in mind the length of the wire and its resistance were somewhat fixed. The resistance of this length should be low enough to be used with a storage battery when the two coils would be connected in parallel, while the number of turns should be ample enough to exert sufficient magnetizing force. Thus it became evident that 1,000 ft. of #16 B & S, P. E. copper wire would do the job. But, being addicted to the use of the electrolytic rectifier type[1] (aluminum-lead), we are happy to report that the reactance of the coils when connected in series is ade-

[1] A. F. Corby, Jr., *Principles of Permanent Magnet Movable Coil and Movable Iron Types of Instruments*, Monograph B-7, Weston Electrical Instrument Corporation, Newark, N. J., 1928, p. 82, "An Electrolytic Rectifier."

quate to prevent damage to fuses and wiring. The current drawn by our model is 5 amperes unfiltered. The rectangular coil forms, determined by the physical dimensions of the magnets, $2 \times 1.4 \times 19$ cm., were made of sheet brass. The ends were circular disks of brass, but these disks were set back 0.90 cm. from the ends of the coil to allow for plywood protecting endpieces. Five hundred feet of #16, P. E. copper wire were wound on each coil form. Since the magnetic flux would be continuous through the two magnets while their prongs were touching, care had to be exercised in joining the ends of the two coils, which in our case were to be connected in series for the reactance, as mentioned above.



When these two coils were then fitted over the prongs of the U-magnets a small unfilled space was found to exist between the coils. This space was used to anchor the coils into a rigid unit by fitting a hardwood (maple) rod between them. The rod was made of such dimensions as to fill the space. The rod was firmly attached to the plywood ends with brass screws. The ends were designed to be ellipses (axes, $3\frac{3}{4} \times 5$ in.) to avoid rolling. Such a design also provided the necessary space for mounting two brass binding posts. To prevent damage through the accidental loos-

ening of the wire leads, these posts were mounted on opposite sides of the coil. The whole coil was protected by a spiral winding of wide surgical (zinc-oxide) tape, and the whole assembly was then shellacked.

Use

The magnetizing coil is connected to the rectifier directly, i.e., without a switch on the d.c. side because of the arcing due to the high self-inductance. The circuit is broken on the a. c. side. An ordinary table plug answers admirably as a switch.

A small magnetic compass is brought near one end of the coil while the current is on to indicate the direction of the magnet-

ism. This is necessary as some U-magnet ends are marked N and S.

In practice, two U-magnets are inserted and left with a small gap between them. When the current begins on the a. c. side of the rectifier the magnets are drawn together with considerable force, producing a loud click. This jolt can be utilized as the hammering or jarring blow to aid in the aligning of the molecules. The current is then broken on the a. c. side by pulling the plug. The time of the current flow may be made as short as desired.

After the current has ceased, the magnets will be found to be so strongly held together that it requires considerable force to separate them. Also, it may be noted and demonstrated, that once the magnets are pulled apart their magnetism or pull is considerably less than before the first separation. This is quite a demonstration in its own right. The whole procedure is very instructive and may be incorporated profitably into the experiment on motors and generators.

Once constructed, the life of the coil is indefinite. The cost, about one dollar in addition to the price of the wire, is not prohibitive for a single school; added use can be gained if such a coil can be loaned to different schools in a system. The whole assembly is quite compact, $3\frac{3}{4} \times 5 \times 7\frac{1}{2}$ inches; the weight is about ten pounds.

ARMY'S A-26 "INVADER" FIGHTER-BOMBER

First facts about the A-26 Invader, the newest and fastest all-purpose bomber now being used by the Army Air Forces primarily to pave the way for invading troops, were revealed when the War Department lifted a corner of the veil of secrecy that surrounds the exceptional new plane.

The Invader combines speed, made possible with twin 2,000 horsepower Pratt and Whitney engines, and heavy firepower, which makes it a valuable weapon for use against enemy aircraft, ground forces, antiaircraft emplacements, supply dumps, wharves, and adaptable to almost any combat situation.

An unusual feature of the A-26 is the all-purpose nose that makes it possible to equip the plane on the production line with special devices for use on special missions, in addition to standard armament. This speeds up the time it takes to get the plane into the air, because it eliminates a trip to the modification center, where such devices are usually installed.

Details about the speed, range of operation, armament and other operational information are still being withheld. It is stated that the plane carries such an extremely flexible selection of machine guns, cannon, and bombs that its offensive striking power, particularly at low or medium altitudes, makes it a formidable weapon on the side of the Allies.

The A-26 employs the recently developed low-drag (laminar flow) airfoil wing section, a product of research originated and conducted by the National Advisory Committee for Aeronautics. This type of wing section was used first on the P-51 "Mustang" fighter plane. The characteristic of the wing section is that the greatest thickness of the wing has been moved back to about the middle of the wing. The leading edge is thinner than on most wings, and it has a teardrop trailing edge. The top and bottom halves of the wing appear to be nearly the same.

The A-26 also has a new double-spotted flap which reduces landing speed and assists take-off. The entire airplane features the accessibility to all parts, which simplifies maintenance. It is exceptionally "clean," aerodynamically.

Now in mass production at plants of the Douglas Aircraft Company, the organization that fathered the A-26, it will prove a valuable aid to speeding up the offensive in the southwest Pacific.

NOTES FROM A MATHEMATICS CLASSROOM

JOSEPH A. NYBERG
Hyde Park High School, Chicago

91. Oral Drill in Algebra Classes. Each year an increasing number of pupils, even many in the ninth grade, are working in shops and stores after school hours. They have fewer periods for study in school, and fewer hours and less energy at home for homework. By homework is meant the work that the pupils do between the end of one class meeting and the beginning of the next meeting, regardless of whether the work is done at home or during a study period in school. Let us see what can be done to reduce the time needed for homework and how we can use the class period more efficiently. I suggest more oral work in class and the elimination of as much writing as possible at home.

It is a waste of time to have the pupil copy from his text and then add problems like: $-7x^2y+3x^2y-6x^2y$. When such work is done, the pupil devotes nine tenths of the time to copying the problem and one tenth to adding -7, $+3$, and -6. Such problems should be done orally in class and never assigned for homework.

Exercises like:

$$-2x^5\times 3x^2, \quad 4x^2\times -5xy^3 \quad (-\tfrac{1}{4}a^2)^3 \quad \text{and} \quad 3x(x^2-5x+4)$$

should also be done orally in class; not even the answers should be written. The same applies to exercises in division like

$$\frac{-8x^3}{2x} \quad \frac{20x-15y}{5} \quad \frac{2x^2-5x+4}{x}.$$

In general, no problem should be assigned for written work if more time is spent in writing than in thinking about the principles which the work applies.

Equations like

$$5x=30, \quad -6y=12, \quad 8n=-2$$

should be solved orally in class and not even the answers should be written. It takes time to write even $x=6$, and this time (even though it be only a few seconds) could better be spent in solving 30 or 40 additional equations. When solving a list of equations like

$$5x=24-x, \quad -2y=20-6y, \quad 18-n=26n$$

the pupil should not copy the equation as printed above, but should write at once

$$6x=24, \qquad 4y=20, \qquad 18=27n.$$

This saves a few more seconds in each problem.

When learning to use parentheses, the teacher should select a list of equations in the text like

$$7(y-2)=3(y+6), \qquad 6x-(1-2x)=5$$

and then ask the pupil to read the equation, removing parentheses while reading. The pupil would say merely

$$7y-14=3y+18, \qquad 6x-1+2x=5.$$

The equation is, for the present, left unsolved; the object at the time is to learn about parentheses. When such equations are assigned for homework, the pupil should not copy the equation as printed in the text, but should write the equation with the parentheses removed. Or, the following treatment may be used:

The teacher announces that part of the homework will be done in class as follows. The pupils have their books open and paper and pencil ready. One pupil is called on to remove the parentheses from the first equation, and the pupils write $7y-14=3y+18$. The pupils are then told to leave enough space on their paper to finish the work at home, and the next equation is started and treated similarly. In this way the teacher can be sure that the new idea, the removing of parentheses, is being learned; the solving of the equation afterwards is an application of old ideas.

The same plan can be used with many other topics. If the solution of time-rate-distance problems is being studied, the pupils should have their paper ready, various pupils recite various steps in the problem, and as soon as the equation has been derived, the teacher says, "Leave enough space on your paper to finish the problem at home, and begin the next problem."

When equations like

$$\frac{7}{15}-\frac{5-x}{10}=\frac{x}{12}$$

are studied, the class that uses this method would have paper ready. The pupil who recites says, "The multiplier is 60. Then 28 minus 6 times the quantity 5 minus x equals $5x$." The other pupils write

$$28-6(5-x)=5x$$

and the teacher reminds the pupils to leave enough space on the paper to finish the work at home. Note that the pupil has not copied the original equation from the book. When the pupil later checks his answer, he should not copy the original equation but write only the result of the substitution of 2 for x.

When finding products like $(2x-3)(x^2-5x+4)$ pupils are taught to copy the problem from the text, writing $2x-3$ below x^2-5x+4. This copying requires time, and little is learned by copying. Assuming that the pupils have read the explanation in the text, they know that x^2-5x+4 is to be multiplied, first by $2x$ and then by -3. Hence the pupil merely says, "$2x^3-10x^2+8x-3x^2+15x-12$." Nothing is written. We know that this quantity could be simplified by adding the like terms, but the simplification can be omitted at this time. Surely, at this stage, the pupil has learned that $-10-3$ is -13, and does not now require drill on elementary additions. But perhaps the teacher wants the pupil to learn that $-3x^2$ of the second partial product should be written below the $-10x^2$ of the first partial product. To this we may reply that it makes little difference where (at some future time) he writes the various terms provided he adds correctly. Actually, when solving sets of literal equations, we write unlike terms one below the other.

Equations like

$$(4x+3)(4x-7)=(2x-3)(8x-5)$$

offer oportunity for oral work. The pupil should look at this equation and say $16x^2-16x-21=16x^2-34x+15$. While one pupil multiplies, another pupil can write these equations on the blackboard; later, other pupils can be sent to the board to finish the solutions.

When solving quadratics by completing the square, I find the following device entertaining and instructive. Around the room on the blackboard are written equations like

$$x^2+6x\quad=7,\qquad y^2-8y\quad=33,\qquad n^2+5n\quad=-4.$$

Notice the space at the left of each equality sign. Different pupils are then called on to tell what must be added to complete the square. As the answer is given, a pupil at the board writes the term in the space left vacant for this purpose. When the last quantity has been completed, we return to the first equation, and a pupil states the square root of each member. The next

pupil states the square roots for the second equation, and so forth. When the last is finished, we start anew with the first, the pupils stating the two values of x. The object of this procedure is to have a great deal of oral work and a minimum of writing by the pupils. The only advantage of shifting from one equation to the next instead of completing each one in turn is that one operation at a time is emphasized.

The object of these devices is to increase the amount of talking (by the pupils) in class, to decrease the amount of writing, and to lessen the need for much of the writing at home. Further, the lazy or indifferent pupil is more likely to do some homework if he has already done (in class) some of the problem than if he has none started. He has less inertia to overcome. I suggest the following experiment: Suppose the homework consists of 10 problems. Do five completely in class, and ask the pupils to do the remainder at home. At another time under similar conditions, do half of each of the 10 problems in class and ask the pupils to finish them at home. My experiments showed that the pupils did more homework by the second method than by the first. Homework is essential, but we must face the fact that pupils do not have the time they once had for it; the only substitute for it is a more efficient use of the recitation period. Perhaps when the war is ended we can once more expect forty minutes of homework.

92. The Time Allotted to Subtraction. If we are to use the time in class efficiently we may well examine every topic for possible simplifications. For example, how important is subtraction?

In twenty minutes a class can learn why we change the sign of the subtrahend and then use addition. The drill needed to fix the rule can be limited to such exercises as: Subtract -2 from 7; 3 from -8; $4x$ from $-5x$. I would omit exercises like subtracting $7x^2y$ from $4x^2y$ and subtracting $3a^2-5a+6$ from a^2+7a-4. I would omit these because the time can more profitably be spent on other topics.

When sets of equations are reached, subtraction is not needed because one of the multipliers can be negative. However, since it is often convenient to subtract an equation like $3x+4y=11$ from $x+4y=13$ we can spend ten minutes at that time to recall the rule about changing the signs of the subtrahend.

When long division is reached, it is impossible to dodge subtraction, and again we can spend ten minutes to recall the rule.

The exercises in long division will furnish the drill that was omitted earlier in the year. But long division is itself a seldom used operation, and not much time should be spent on it.

In the entire ninth grade forty or fifty minutes, divided among the three places I have mentioned, would seem to be all the time that subtraction deserves.

CHEMISTRY AND ROMANCE

Amber Baldwin
Port Carbon High School, Port Carbon, Pennsylvania

Although I had graduated from college in 1933, I taught school for the first time last year. During the year I had a great deal of trouble teaching chemical formulas and equations, until I decided to put chemistry on a romantic basis.

This can be accomplished, I discovered, by giving chemical terms human values. Thus metals can be considered as boys, non-metals as girls and electrons as rings. If this idea is carried a step farther, there are two boys, who may be considered "fast workers" to use a slang expression of the day. These two boys, Potassium (K) and Sodium (Na) have only one ring or electron to give away. Since they are not anxious to get married, they only give away class rings. There are also other metals with only one ring to give away, but these metals are not so active as Potassium and Sodium. Their names are Mercury (Hg), Silver (Ag) and Copper (cuprous) (Cu).

The girls in whom these boys are interested are the three sisters Chlorine (Cl), Bromine (Br) and Iodine (I). These three non-metals are just as anxious to receive the class rings as the boys are to lend them.

The union between the above mentioned metals and non-metals can be shown best by the use of structural formulas. Thus if Na gives away one ring and Cl is anxious to receive it the ring may be represented by a line and the formula may be represented as Na—Cl or NaCl, which is common salt.

The next group of boys to be studied are the more serious type. They are much slower, but they have two rings to give away—both wedding and engagement rings. In other words they have a valence of two. Their names are Magnesium (Mg), Calcium (Ca), Iron (ferrous) (Fe), Copper (cupric) (Cu), Zinc (Zn), Barium (Ba), Mercury (mercuric) (Hg) and lead (Pb).

The girls having a negative valence of 2 are so anxious to receive these rings that they have both hands stretched out to grasp them. Their names are Oxygen (O) and Sulphur (S). Although these metals and non-metals exchange two electrons, only one atom of each is involved. Therefore the structural formula, showing the rings may be expressed in this manner $Mg{=}O$ and the regular formula MgO.

All the marriages in the group which have a valence of 2, however, are not happy. Sometimes a metal having a valence of 2 wishes to marry a non-metal having a valence of 1. In this case the metal must commit bigamy. Thus, as in the case of Ca and Cl, the structural formula is

$$\begin{array}{ccc} & & Cl \\ & / & \\ Ca & & \\ & \backslash & \\ & & Cl \end{array}$$

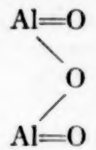
and the regular formula is $CaCl_2$.

The same thing may take place when the non-metal has a valence of 2 and the metal has a valence of 1, except that in this case it is the female of the species who is committing the crime. For example Oxygen, the girl joins with silver to form Ag_2O, expressed structurally as

$$\begin{array}{ccc} Ag & & \\ & \backslash & \\ & & O. \\ & / & \\ Ag & & \end{array}$$

The next group of elements are polygamists. These metals, Iron (ferric), and Aluminum, have three rings to give away. Therefore when combining with a non-metal having a valence of only 1 they must take three wives. For instance Iron (ferric) when joined with Chlorine marries triplets. First Iron sees Chlorine and he thinks she is very lovely so he asks her hand in marriage, but he still has two more rings to give away. Chlorine, being unselfish can only accept one ring so she introduces her sister, who in turn can't bear to leave her third sister. The three girls are so attractive, that Iron decides to marry all of them, thus forming $FeCl_3$.

There are other erotic combinations in this group, as for example the combination of Al with O. In this very strange case two men are married to three wives—both men sharing one of the wives. This may be shown in the following manner:



or Al_2O_3.

The radicals both negative and positive may be worked out on this same plan, the positive radical, ammonium (NH_4), the only positive radical in elementary chemistry, can be considered as a boy and the others as girls. In these cases the group of elements are considered as a whole. Thus the boy NH_4 joins with the girl radical OH to form ammonium hydroxide NH_4OH.

After the combination of elements into formulas is understood, equations can be more easily comprehended. Equations make up a whole field of human relationships by their marriages, divorces and remarriages. There are simple marriages of direct combination like the following equation:

$$C+O_2 \rightarrow CO_2.$$

Then there is simple replacement, which involves divorce and remarriage. An example of this is the reaction of zinc and sulphuric acid, which forms zinc sulphate and Hydrogen.

$$Zn+H_2SO_4 \rightarrow ZnSO_4+H_2.$$

The change of mates in double replacements expresses an oddity in human conduct. For instance sodium chloride reacts with silver nitrate to form a white precipitate, silver chloride and sodium nitrate. The equation for this is shown below:

$$NaCl+AgNO_3 \rightarrow AgCl+NaNO_3.$$

Equations and formulas, therefore cover the entire field of romance. This relationship between romance and chemistry proves to be a very simple device for teaching such combinations and reactions.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1883. *Walter R. Warne, Marshall, Mo.*

1879. *Inez Conley, Kendaia, N. Y.; J. W. Jacks, Batavia, N. Y.; Harry Kinne, Hayt Corners, N. Y.*

1890, 1899. *Grace N. Williams, Cape Girardeau, Mo.*

1899. *Dorothy C. Hand, Clark's Summit, Pa.*

1885, 8, 9, 90. *Joseph Lerner, New York City.*

1891. *Proposed by Orlando Kelley, Romulus, N. Y.*

Solve for x:

$$\begin{vmatrix} x^2-a^2 & x^2-b^2 & x^2-c^2 \\ (x-a)^3 & (x-b)^3 & (x-c)^3 \\ (x+a)^3 & (x+b)^3 & (x+c)^3 \end{vmatrix}=0.$$

Solution by (no name on paper)

Add the third row to the second and then remove the factor $2x$ from the elements of the second row. We then obtain

$$2x\begin{vmatrix} x^2-a^2 & x^2-b^2 & x^2-c^2 \\ x^2+3a^2 & x^2+3b^2 & x^2+3c^2 \\ (x+a)^3 & (x+b)^3 & (x+c)^3 \end{vmatrix}=0.$$

Adding three times the first row to the second and removing the factor $4x^2$ from the elements of the second row, we have

$$8x^3\begin{vmatrix} x^2-a^2 & x^2-b^2 & x^2-c^2 \\ 1 & 1 & 1 \\ (x+a)^3 & (x+b)^3 & (x+c)^3 \end{vmatrix}=0.$$

Now subtract the second column from the first and the third column from the second; after removing the factors $(a-b)$ from the elements of the first column and $(b-c)$ from the elements of the second column, we obtain

$$8x^3\begin{vmatrix} -(a+b) & -(b+c) & x^2-c^2 \\ 0 & 0 & 1 \\ 3x^2+3(a+b)x+a^2+ab+b^2 & 3x^2+3(b+c)x+b^2+bc+c^2 & (x+c)^3 \end{vmatrix}=0.$$

Now expand according to the elements of the second row;

$$8x^3\begin{vmatrix} -(a+b) & -(b+c) \\ 3x^2+3(a+b)x+a^2+ab+b^2 & 3x^2+3(b+c)x+b^2+bc+c^2 \end{vmatrix}=0$$

or, upon expanding and combining like terms,

$$8x^3\{3x^2(a-c)-(a-c)(bc+ca+ab)\}=0$$

$$8x^3\{3x^2-(bc+ca+ab)\}=0$$

$$\therefore\quad x=0,\qquad \pm\sqrt{\frac{bc+ca+ab}{3}}.$$

A solution was also offered by B. Felix John, Philadelphia, Pa.; Pfc. Roy E. Wild, Durham, N. H.

1892. *Proposed by Orlando Kelley, Romulus, N. Y.*

Find to infinity the sum:

$$\frac{1}{3}+\frac{1\cdot 3}{3\cdot 6}+\frac{1\cdot 3\cdot 5}{3\cdot 6\cdot 9}+\cdots.$$

Solution ny Aaron Buchman, Buffalo, N. Y.

If

$$\frac{1}{\sqrt{1-x}}$$

is expanded into a Maclaurin's series, the following equation results:

$$\frac{1}{\sqrt{1-x}}=1+\frac{x}{\lfloor 1}\cdot\frac{1}{2}+\frac{x^2}{\lfloor 2}\cdot\frac{1}{2}\cdot\frac{3}{2}+\frac{x^3}{\lfloor 3}\cdot\frac{1}{2}\cdot\frac{3}{2}\cdot\frac{5}{2}+\cdots$$

$$=1+\frac{1}{2}\,x+\frac{1\cdot 3}{2\cdot 4}x^2+\frac{1\cdot 3\cdot 5}{2\cdot 4\cdot 6}x^3+\cdots.$$

The series on the right side of the equation is convergent for x between $+1$ and -1, and in particular for $x=\frac{2}{3}$. When $x=\frac{2}{3}$, the equation becomes

$$\sqrt{3}=1+\frac{1}{3}+\frac{1\cdot 3}{3\cdot 6}+\frac{1\cdot 3\cdot 5}{3\cdot 6\cdot 9}+\cdots.$$

Thus

$$\frac{1}{3}+\frac{1\cdot 3}{3\cdot 6}+\frac{1\cdot 3\cdot 5}{3\cdot 6\cdot 9}+\cdots=\sqrt{3}-1.$$

Solutions were also offered by Pfc. Roy Wild, Durham, N. H.; B. Felix John, Philadelphia, Pa.

1893. *Proposed by Rita Dorner, Syracuse, N. Y.*

Solve $3x^3-32x^2+33x+108=0$, if one root is the square of another.

Solution by Margaret Joseph, Milwaukee, Wis.

By synthetic division 3, 9 and $-\frac{4}{3}$ are found to be the roots.

Using the symmetric relations between the roots and coefficients, one obtains, with a, a^2, b as roots:

$$a^3b=-36$$

$$a^2+a+b=\frac{32}{3}\cdot$$

When b is eliminated, one obtains:

$$3a^5+3a^4-32a^3-108=0.$$

The use of synthetic division yields the same roots as above.

Solutions were also offered by B. Felix John, Philadelphia; Mildred Potter, Syracuse, N. Y.; Walter R. Warne, Marshall, Mo.; Robin A. Eshenour, Waterloo, N. Y.; Paul Mount-Campbell, Roswell, N. M.

1894. If a_1, a_2, a_3 are the roots of $x^3+px+q=0$, find

$$\sum \frac{1}{a_1^2+a_2a_3}.$$

Solution (no name given)

We know that $\sum a_1=0$, $\sum aia_2=p$, $a_1a_2a_3=-q$. Using these results, we can easily show that:

$$\sum a_1^2=(\sum a_1)^2-2\sum a_1a_2=-2p;$$
$$\sum a_1^2a_2=\sum a_1\cdot\sum a_1a_2-3a_1a_2a_3=3q;$$
$$\sum a_1^3=(\sum a_1)^3-3\sum a_1^2a_2-6a_1a_2a_3=-3q;$$
$$\sum a_1^3a_2=\sum a_1^2\cdot\sum a_1a_2-a_1a_2a_3\sum a_1=-2p^2;$$
$$\sum a_1^2a_2^2=(\sum a_1a_2)^2-2a_1a_2a_3\sum a_1=p^2;$$
$$\sum a_1^3a_2^3=\sum a_1^2a_2^2\cdot\sum a_1a_2-a_1a_2a_3\sum a_1^2a_2=p^3+3q^2.$$

Now

$$\sum \frac{1}{a_1^2+a_1a_3}=\sum\frac{a_1}{a_1^3+a_1a_2a_3}=\sum\frac{a_1}{a_1^3-q}$$
$$=\frac{a_1}{a_1^3-q}+\frac{a_2}{a_2^3-q}+\frac{a_3}{a_3^3-q}$$
$$=\frac{a_1a_2a_3\sum a_1^2a_2^2-q\sum a_1^3a_2+q^2\sum a_1}{a_1^3a_2^3a_3^3-q\sum a_1^3a_2^3+q^2\sum a_1^3-q^3}$$
$$=\frac{p^2q}{-8q^3-p^3q}$$
$$=-\frac{p^2}{p^3+8q^2}.$$

Solutions were also offered by Aaron Buchman, Buffalo, N. Y.; B. Felix John, Philadelphia, Pa.; Paul Mount-Campbell, Roswell, N. M.

1895. *Proposed by J. S. Miller, New Orleans, La.*

Solve for x:

$$k(x^4+1)=(x+1)^4.$$

Solution by the Proposer

Solve:

$$k(y^4+1)=(y+1)^4. \tag{1}$$

Expand, collect terms, and write in the form

$$(1-k)y^4+4y^3+6y^2+4y+(1-k)=0. \tag{2}$$

This can be written

$$(1-k)\left(y^2+\frac{1}{y^2}\right)+4\left(y+\frac{1}{y}\right)+6=0. \tag{3}$$

Now invoke the identity

$$x^{P+1}+\frac{1}{x^{P+1}}=\left(x^P+\frac{1}{x^P}\right)\left(x+\frac{1}{x}\left(-\left(x^{P-1}+\frac{1}{x^{P-1}}\right)\right.\right. \tag{3a}$$

for integral values of $P>0$ and put

$$\left(x+\frac{1}{x}\right)=z. \tag{3b}$$

Then (3) becomes

$$(1-k)(z^2-2)+4z+6=0. \tag{4}$$

Now (4) reduces to

$$(1-k)z^2+4z+(4+2k)=0 \tag{5}$$

which is in general quadratic form from which

$$z=\frac{-2\pm\sqrt{2a+2a^2}}{1-a}. \tag{6}$$

Returning now to (3b) we have

$$x+\frac{1}{x}=\frac{-2+\sqrt{2a+2a^2}}{1-a}$$

using upper sign only which reduces to

$$x^2(1-a)+x(2-\sqrt{2a+2a^2})+(1-a)=0 \tag{7}$$

which again is in general quadratic form.

Solution of (7) yields

$$x=\frac{-2+\sqrt{2a+2a^2}+\sqrt{10a-2a^2-4\sqrt{2a+2a^2}}}{2(1-a)}$$

which is one of the roots of (1), with x written for y.

The other three roots are similarly found.

The four roots are

$$\frac{-2+\sqrt{2a+2a^2}\pm\sqrt{10a-2a^2-4\sqrt{2a+2a^2}}}{2(1-a)}$$

$$\frac{-2-\sqrt{2a+2a^2}\pm\sqrt{10a-2a^2+4\sqrt{2a+2a^2}}}{2(1-a)}.$$

Solutions were also offered by B. Felix John, Philadelphia, Pa.; Walter R. Warne, Marshall, Mo.

1896. *Proposed by Daniel Finkel, Washington, D. C.*

An examination consists of four papers with a maximum of m marks for each paper. What is the number of ways of getting $2m$ marks on the examination?

Solution

The required number of ways is equal to the coefficient of x^{2m} in the expansion of

$$(1+x+x^2+\cdots+x^m)^4$$

or, upon summing the geometric progression, in

$$\left(\frac{1-x^{m+1}}{1-x}\right)^4=(1-x^{m+1})^4(1-x)^{-4}$$

$$=(1-4x^{m+1}+6x^{2m+2}-4x^{3m+3}+x^{4m+4})\Big(1+4x+\frac{4\cdot 5}{1\cdot 2}x^2+\cdots$$

$$+\frac{4\cdot 5\cdot 6\cdots(m+2)}{(m-1)!}x^{m-1}+\cdots$$

$$+\frac{4\cdot 5\cdot 6\cdots(2m+3)}{(2m)!}x^{2m}+\cdots\Big)$$

The coefficient of x^{2m}

$$=\frac{4\cdot 5\cdot 6\cdots(2m+3)}{(2m)!}-\frac{4\cdot 4\cdot 5\cdot 6\cdots(m+2)}{(m-1)!}$$

$$=\frac{1\cdot 2\cdot 3\cdots(2m+3)}{6(2m)!}-\frac{4\cdot 1\cdot 2\cdot 3\cdots(m+2)}{6(m-1)!}$$

$$=\frac{(2m+1)(2m+2)(2m+3)}{6}-\frac{4m(m+1)(m+2)}{6}$$

$$=\tfrac{1}{3}(m+1)\{(2m+1)(2m+3)-2m(m+2)\}$$

$$=\tfrac{1}{3}(m+1)(2m^2+4m+3).$$

A solution was also offered by B. Felix John, Pittsburgh, Pa.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

No names appear for this issue.

PROBLEMS FOR SOLUTION

1909. *Proposed by Helen M. Scott, Baltimore, Md.*

Find the radius of the circle inscribed in the loop given by

$$a^2y^2=x^2(a^2-x^2).$$

1910. *Proposed by Hugo Brandt, Chicago, Ill.*

Prove the identity by use of geometry:

$$\sin\tfrac{1}{2}(A+B)(\sin A-\sin B)=\cos\tfrac{1}{2}(A+B)(\cos B-\cos A).$$

1911. *Proposed by Charles P. Louthan, Columbus, Ohio.*

Find the length of the arc of the parabola $y^2=qx$, which is intercepted between the points of intersection of the parabola and $y=kx$.

1912. *Proposed by Hugo Brandt, Chicago, Ill.*

Find the sum,

$$\sum_{1}^{\infty} \frac{n}{(n+1)!}.$$

1913. *Proposed by Paul H. Renton, West View, Pa.*

Two circular cylinders intersect so that their axes form an angle of 45°. If the diameter of one is two inches and of the other, one inch, find the volume common to both.

1914. *Proposed by Paul H. Renton, West View, Pa.*

Prove that the time in which a man could cross a road of breadth c, in a straight line with the least velocity possible, between a stream of vehicles of breadth b, following at intervals of a at velocity v is

$$\frac{c}{v}\left(\frac{a}{b}+\frac{b}{a}\right).$$

BOOK REVIEWS

RADIO: FUNDAMENTAL PRINCIPLES AND PRACTICES, by Francis E. Almstead, *Lieutenant, U.S.N.R., Bureau of Naval Personnel, Washington, D. C.;* Kirke E. Davis, *Head, Science Department, Oceanside High School, Oceanside, N. Y.;* and George K. Stone, *Senior Education Supervisor, The State Education Department, Albany.* Cloth. Pages vii+219. 13×20 cm. 1944. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $1.80.

"The purpose of this book is to aid the student in acquiring a sound foundation in the fundamental principles and practices of radio as a basis for further training or immediate use." This is the aim as stated by the authors in the Preface. It is assumed that students of radio will have had good courses in physics and high school mathematics as prerequisites. They will be well acquainted with the fundamentals of electric circuits and theory and know some of the essential principles of light and sound. Algebraic symbols and equations are the usual method of expression and bring them no difficulties. With such a basis for study it is possible to cover both theory and practice of radio in a few pages, but unless the student has mastered such preliminary courses this book is not for him. The first two chapters, consisting of about twenty pages, give a hurried review of the essentials of direct current; chapters three and four cover the theory of alternating current circuits. Then follows a short chapter on vacuum tubes, which gives only the essential elements of tube operation. In similar manner the authors treat inductance, capacitance, resonance, coupled circuits, power supply, etc. Clear well-labeled diagrams are used throughout and a short list of questions follows each chapter. It gives the essential theory for those who have sufficient preparation but its study should be accompanied by a complete laboratory course.

G. W. W.

THE RADIO AMATEUR'S HANDBOOK, Twenty-first Edition by the Headquarters Staff of the American Radio Relay League. Paper. Pages 480+184. 16.5×24 cm. 1944. The American Radio Relay League, West Hartford, Conn. Price $1.00.

This is the second printing of the twenty-first edition of the standard

manual of amateur radio communication, the first printing of which appeared in November 1943. It consists of an introductory chapter giving some of the history of the league, its membership and publications, the code and how to memorize and use it. The second section on Principles and Design is composed of nine chapters, nearly 200 pages, describing and explaining the theory of radio and the principal instruments and circuits used. The third section is composed of eleven chapters, 260 pages, giving construction data for many types of receivers and transmitters, radio measurements and measuring equipment, workshop practice, and tube characteristics. A short chapter on operating practice concludes the text. An advertising section of 174 pages lists the standard manufacturers and their principal products.

The effect of the war is very noticeable in this edition. There is more emphasis on the fundamental knowledge of radio rather than on construction. A new chapter on carrier-current communication has been added; the chapter on the War Emergency Radio Service has been improved; and new tube data have been added. The theory section is a well designed textbook for classroom use and sections of the construction division give all the essentials for laboratory work.

G. W. W.

STEEL IN ACTION, by Charles M. Parker, *American Iron and Steel Institute.* Cloth. Pages v+221, 19×13 cm. 1943. The Jaques Catell Press, Lancaster, Pennsylvania. $2.50.

Here is a little book that deserves a place on the book shelves of high school libraries. Students of chemistry will find excellent background reading in its chapters on the manufacture of iron and the various steel alloys, although no chemistry training is necessary for understanding the book.

About two-thirds of the book deals with the place of the iron and steel industry in the world, with chapters on raw materials distribution, manufacturing centers and trade. The book closes with chapters on recent war expansion, new developments and the possible future of the industry.

This reviewer is not qualified to judge the accuracy of the content but he found the book most interesting reading. It has few illustrations but the files of most high school chemistry teachers will contain sufficient illustrative material. It can be recommended to the more academic-minded pupils for special reading.

WALTER A. THURBER

GENERAL CHEMISTRY PROBLEMS, by William M. Spicer, *Associate Professor of Chemistry, Georgia School of Technology;* William S. Taylor, *Professor of Chemistry, Georgia School of Technology;* and Joe D. Clary, *Assistant Professor of Chemistry, Georgia School of Technology.* Cloth. Pages v+120. 13.5×21 cm. 1943. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.25.

This book contains the different types of problems which are similar to those found in general chemistry problem books. Preceding each list of problems there are illustrative problems. The authors give good discussions on exponential numbers, logarithms, and the slide rule.

In the back of the book there is a list of review problems. The different groups of problems cannot be classified under a single simple type. Each group contains problems which involve a combination of two or more types.

In this book the authors attempt to teach:

1. The necessity for the justification of every step taken in the solution of a problem.

2. The importance of thinking in terms of chemical units or quantity, moles, gram-atomic weight, gram-equivalent weights, etc.
3. The elementary ideas about significant figures.
4. The use of logarithms and the slide rule.
5. The importance of mentally checking all results.

E. G. M.

So You Want To Be a Chemist, by Herbert Coith, *Associate Chemical Director, The Procter and Gamble Company.* Cloth. Pages x+128. 12×18.5 cm. 1943. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y.

This book is practical. It is an analysis of the varied functions and responsibilities of the chemist, of the importance of his jobs, and of the characteristics which are required to perform them.

The author has divided the work of the chemist in industry into four fields, namely: (1) the standards for raw materials, for processes, and for finished products; (2) research on raw materials, on processes, and on finished products; (3) plant development on raw materials, on processes, and on finished products; (4) products service on raw materials, on processes, and on finished products.

Emphasis is laid on the importance of analytical chemistry to industry. "Analytical Chemistry, using the term in its broadest meaning, is the cornerstone of all chemistry. It is the essential tool without which the handicraft of the chemist cannot proceed."

The book contains good discussion on the following: the importance of research to plant development, the relation of chemistry to products service, the kind of a chemist that industry wants, the kind of industry that chemists want, and the chemists in wartime.

This book should be read by every young person who wants to study chemical engineering or major in chemistry.

E. G. M.

Chemistry of Synthetic Substances (in German), by Dr. Emil Dreher, Translated (1943) by Marion Lee Taylor. Cloth. 103 pages. 14×21 cm. Published by the Philosophical Library, 15 E. 40th Street, New York City. Price $3.00.

The original German edition of this book was a collection of previously published papers, edited and republished in book form as a non-critical review of the chemistry of high polymers. As such it served a useful purpose. It is, however, neither better nor more complete than several other similar reviews already available in English at the time this translation was published. Unfortunately the German text suffers materially by a too literal translation. For example, the German word "Lack" sometimes means lac (shellac) but in speaking of the cellulose esters (p. 20) "Lack" is better translated as lacquer. Other inaccuracies not so obvious required reference to the original for an understanding of the text.

The theory of structure from the Staudinger viewpoint is briefly stated. The conventional formulations for the various high molecular materials are given, without however, any description of the investigations which led to their adoption. The various chapters include a summary of the mechanism of polymerisation, the influence of substituents, and tables giving the reactivity of various materials which are the basis for many industrial high polymers.

Especially emphasized is the subject of synthetic high polymeric substances in the preparation of protective coatings, and the polymerisation of drying oils.

Printing and binding are satisfactory, but neither the subject matter nor the printing would seem to justify the publisher's price of $3.00.

JOHN H. SCHMIDT

ARITHMETIC FOR ADULTS (A Review of Elementary Mathematics), by Aaron Bakst. Cloth. vii+320. 2×14×20 cm. 1944. F. S. Crofts & Co., Inc., New York, N. Y. Price $2.00.

This book is designed as a helper of the adult in the everyday affairs of life. It attempts to help those who have forgotten their elementary school mathematics, or those who did not understand it then and want to do so now, or those who have been the victims of poor teaching and wish to make amends by self study.

Practical problems and understandable techniques are employed in the perusal of the topics addition, subtraction, multiplication, division, decimal fractions, common fractions, ratio, proportion, per cents, square roots, logarithms, and the slide rule.

JOSEPH J. URBANCEK
Chicago Teachers College

AIRCRAFT ANALYTIC GEOMETRY (Applied to Engineering, Lofting, and Tooling), by J. J. Apalategui, *Tooling Project Supervisor, Lofting Departments, Douglas Aircraft Company, Inc.*, and L. J. Adams, *Head of the Department of Mathematics, Santa Monica Junior College.* Cloth. 2×14×21 cm. xviii+286. 1944. First Edition. McGraw-Hill Book Co., Inc., New York. Price $3.00.

The book is based upon ideas and mathematical methods developed in the tooling division of the Douglas Aircraft Company. It presents an exact approach to a large class of geometrical problems which arise in the lofting, engineering, and tooling of airplanes. A paragraph from the foreword follows.

The application of analytic geometry as a precise method in the location of fundamental points, lines, and planes and in the calculation and rotation of angles was initiated by the author in 1937 during the tooling of the prototype C-54 and developed to its highest point on the B-19 superbomber. The complete analysis and definition of the loft lines layouts by the equations of conics were introduced in 1940.

The material is intended for use by men in the lofting, tool designing, and jig-building departments and will also be very useful for men in the layout and development groups of the engineering department.

JOSEPH J. URBANCEK

GENERAL MATHEMATICS IN AMERICAN COLLEGES, by Kenneth E. Brown, Ph.D. Contributions to Education, No. 893. Published with the Approval of Professor William D. Reeve, Sponsor. Cloth. viii+168. 2×16×23 cm. 1943. Bureau of Publications, Teachers College, Columbia University, New York. Price $2.35.

Data for the study were obtained from a survey of pertinent literature in the field, an examination of mathematical offerings listed in the cataogues of 1,266 universities, colleges, and junior colleges, questionnaire answers from 458 colleges in the United States offering general mathematics, analysis of more than fifty general mathematics textbooks, recorded observations of fifty general mathematics classroom recitations, and opinions of 1,500 students enrolled in general mathematics classes.

The conclusions are general and unimpressive.

JOSEPH J. URBANCEK